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Effects of a 10-Week Introductory Judo Course on Postural Control During Reactionary Bilateral Gripping Task With Varied Stances and Lower Body Power Performance

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EFFECTS OF A 10-WEEK INTRODUCTORY JUDO COURSE ON POSTURAL CONTROL DURING A REACTIONARY BILATERAL GRIPPING TASK WITH VARIED STANCES AND LOWER BODY POWER PERFORMANCE

by
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ABSTRACT

PURPOSE: The purpose of the present study is twofold: 1.) Examine the effects of 10-weeks of an introductory judo course on postural control during maximal bilateral isometric handgrip testing using different stance conditions and lower body power performance, and 2.) To analyze the relationship between maximal bilateral handgrip exertions on postural control during varied stance conditions. **METHODS:** Twenty recreationally active men and women divided into two an experimental group, (JDO) (n = 10; 21.70 ± 3.83 y; 169.91 ± 6.01 cm; 73.89 ± 12.10 kg; 19.01 ± 8.06% BF), and a control group, (CON) (n = 10; 21.50 ± 2.84 y; 170.06 ± 8.28 cm; 76.62 ± 12.03 kg; 22.41 ± 6.64% BF), participated in this study. Both groups completed pre-testing, performing nine randomly assigned experimental trials measuring center of pressure (COP) variables during the performance of a bilateral reactionary gripping task using varied stance conditions. Each trial consisted of bilateral maximal voluntary contractions (MVC) measured simultaneously with a handgrip dynamometer, three times with a neutral (N), dominant foot forward (D), and non-dominant (ND) foot forward stance. Furthermore, participants performed three bilateral countermovement jumps (CMJ) trials. All trials were completed while standing on a portable force platform, which was used, in conjunction with corresponding software, to track COP amplitude in the mediolateral (COP_{ML}) and anteroposterior (COP_{AP}) directions, COP mean velocity (MV), and COP area (AREA) while gripping the dynamometer, and ground reaction forces, peak force (CMJ_{PKF}), peak power (CMJ_{PP}), and rate of power development (CMJ_{RPD}), during CMJ performance. Subjects were instructed to grasp the dynamometers as forcefully as possible for ~5-sec during each trial. All trials were separated by a recovery period of 60-sec. A Waterloo Handedness and Footedness Questionnaire was used to determine subject upper and lower body laterality. Participants repeated the testing protocol following the conclusion of the 10-week course. **RESULTS:** No significant interactions were observed in MVC strength of the DOM and NON hands during any of the three stance conditions following the 10-week judo course. Furthermore, no significant interactions were observed for any of the COP variables. However, a significant main effect of stance was observed for COP_{ML}, MV, and AREA. Results did reveal that CMJ_{PP} significantly improved in the JDO group (PRE: 3584.70 ± 716.59W - POST: 3750.10 ± 699.61W) following the 10-week judo course, while no change was observed in the CON group (PRE: 3693.10 ± 1083.77W – POST: 3654.40 ± 1023.94W). However, no change was seen in CMJ_{PKF} or CMJ_{RPD}. **CONCLUSIONS:** The results of this investigation indicate that 10-weeks of an introductory judo course may increase CMJ_{PP}, however, has no effect on postural control or bilateral MVC strength of the DOM and NON hand during varied stance conditions. Furthermore, results reveal that bilateral MVC exertion has no influence on postural control performed during varied stance conditions.

This thesis is dedicated to the three most important people in my life; my sister, Kirby, my grandmother, Marjorie, and my father, William. I could not have achieved all that I have and will without their love and support.

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LIST OF ACRONYMS/ABBREVIATIONS

AP – Anteroposterior

CMJ – Countermovement Jump

CON – Control Group

COP – Center of Pressure

D – Dominant Foot Forward Stance Condition

DOM – Dominant Hand

JDO – Judo Group

ML – Mediolateral

MV – Mean Velocity

MVC – Maximal Voluntary Contraction

N – Neutral Stance Condition

ND – Non-Dominant Foot Forward Stance Condition

NON – Non-Dominant Hand

PKF – Peak Force

POST – Post-Testing

PP – Peak Power

PRE – Pre-Testing

RPD – Rate of Power Development

CHAPTER I: INTRODUCTION

Postural control is the task of controlling the body's position in space for the dual purposes of stability and orientation (Shumway-Cook & Woollacott, 1995). The postural-control system involves a complex interaction between musculoskeletal and neural systems. It has two primary functions: first, to ensure that balance is maintained, and second, to fix the orientation and position of body segments, which serve as a reference frame, in order for accurate perception and action to take place with respect to the external environment (Massion, 1994). The most common method for evaluating postural control is monitoring center of pressure (COP) motion for a specified duration as an individual stands on a force platform under several pre-planned conditions (Aalto et al., 1990; Paillard et al., 2002; Caron et al., 2008).

Force platforms have been used to acquire quantitative measures and analyses of postural control (Palmieri et al., 2002). Force platforms provide an indirect assessment of changes in postural sway by recording the ground-reaction forces projected from the body (Browne & O'Hare, 2000; Goldie, Bach, & Evans, 1989). The COP is calculated from these ground-reaction forces. COP reflects the trajectory of the center of mass and the amount of torque applied at the support surface to control body-mass acceleration (Winter, Patla, & Frank, 1990). Various parameters, including sway amplitude, mean sway velocity, and sway area have been derived from COP data in order to quantify alterations in balance (Palmieri et al., 2002).

Balance and postural control rely on the body's ability to integrate information from the sensory-motor chain, vestibular, somatosensory, and visual systems (Nasher, 1997). The vestibular system is sensitive to position and movements of the head with respect to gravity and inertial forces. The somatosensory system consists of multiple receivers that sense the position, speed of all body segments, and contact with external objects (Winter, 1995). The visual system provides information about the position and movement of objects in space, and the position and movement of the limbs relative to the environment and the rest of the body. Training of each of the levels of the sensory-motor chain improves balance control in complex conditions (i.e. with sensory deprivation) indicating a positive effect of training on sensorimotor adaptability (Perrin et al., 2002). Moreover, Perrin et al. (2002) observed that the improvement of postural control could depend on the sport practiced.

High-level athletes display improved balance control in relation with the requirement of each discipline while predominantly using certain sensory information (Perrin et al., 1998; Vuillerme et al., 2001) and that training in a specific activity develops specific modalities of postural control (Asseman et al., 2004; Perrin et al., 2002). Sports training, especially those requiring fast and highly skilled movements, have been reported to improve postural control (Golomer et al. 1999; Perrin et al., 2002). Ability to control balance promotes the maintenance of stable body position (static balance) and maintain and/or regain this state during the performance of an activity (dynamic balance) (Sterkoicz et al., 2012).

The martial art and combat sport of judo has been included in the Olympic Games since 1964 (Nishime, 2007). As a consequence of the high-intensity intermittent efforts, judo athletes develop specific physiological characteristics (Franchini et al., 2011). Judo training requires participants to engage in intermittent bouts of activity during which strength, power, balance, and coordination are needed to throw an opponent to the ground or impose submission via pin, choke, or arm lock (Fukuda et al. 2013). Strategy is involved in the execution of techniques while engaging the opponent through the use of gripping the uniform and avoiding subsequent reactions and attacks. During a typical judo match, most time is spent in gripping disputes, coincidental with upper and lower-body actions needed during technique application while engaging the opponent (Franchini et al., 2005; Calmet, Miarka, & Franchini, 2010; Franchini et al., 2008; Marcon et al., 2010; Miarka et al., 2012).

Typically, judo bouts occur in the vertical position (Sterkowicz & Franchini, 2000) requiring athletes to adapt their posture quickly in reaction to combat situations, through the ability to maintain and regain balance. This is particularly important when performing techniques used during practice or competition (Blach, 2005; Pawluk, 1988). Thus, balance control is a fundamental principle in judo, and an athlete's dynamic balance likely reflects their ability to execute throwing techniques with the purpose of compromising their opponent's balance and causing them to fall to the ground. In order to achieve this goal, practitioners must control their dynamic posture, while gripping the judo uniform, as their opponents attempt to displace their balance (center of gravity) in order to complete various throwing techniques.

Judo training has been shown to lead to greater reliance on somatosensory information whereas other sports, such as dance, rely more heavily on visual information (Golomer et al., 1999; Perrin et al., 2002). The nature of the movements involved in different sports would influence postural adaptation. Moreover, there is a relationship between the competitive level and postural performance in judo (Cremieux & Mesure, 1992) and other fighting sports, particularly during offensive movements (Perrot et al., 1998). Further, experts have been observed to have more efficient postural capabilities as compared to novices (Paillard, Montoya, & Dupui, 2007) demonstrating the influence of judo experience on postural regulation.

Handgrip strength is frequently assessed as an indicator of upper limb strength during the evaluation of performance in many different sports (Fry et al., 2006; Leyk et al., 2007; Visnapuu & Jürimäe, 2007). The strength of an individual's handgrip is the result of the maximum voluntary force they are able to generate using their finger, joints, thumb, and wrists under normal biokinetic conditions (Shyamal & Yadav, 2009). Many sporting activities require the maintenance of adequate levels of handgrip strength to maximize control, task performance, and decrease injury risk (Blackwell, Johansen, & Heath, 1999). Handgrip strength has been investigated in a variety of studies evaluating the general physical fitness of judo athletes (Franchini, Takito, & Bertuzzi, 2005; Franchini et al., 2005b). During competition, a judo athlete grips the opponent's uniform (judogi), which provides the basis for the execution of throwing techniques, placing a large anaerobic demand on the upper body (Bontich-Góngora et al., 2010; Franchini et al., 2003). Previous research has failed to confirm the relationship between maximal grip strength and judo performance. Nonetheless, the technical-tactical requirements of judo are quite complex, and grip fighting (kumi-kata) is usually the first contact between two judo athletes and may determine the ultimate result of the bout (Farmosi, 1980; Franchini et al. 2011; Little, 1991).

Lower-body force and power are considered essential for high level performance in judo (Fagerlund & Hackney, 1991; Little, 1991; Sbriccoli et al., 2007; Thomas et al., 1989). Fagerlund & Hakkinen (1991) concluded that leg force and power can discriminate between judo athletes of different competitive standards. Considering this, several studies have assessed lower body power of judo athletes using the Wingate test (Franchini et al., 2003; Little, 1991; Sbriccoli et al, 2007; Thomas et al.,1989), or by determining the height achieved during a squat or counter-movement jump test (Filaire, et al., 2001; Iglesias, Clavel, Dopico, & Tuimil, 2003; Monteiro, García & Carratalá, 2007). The incorporation of dynamic electronic dynamometers and force platforms to standard jump testing protocol provides the ability to assess power directly (W) by calculating the product of the force applied (N) and the displacement velocity ($m \cdot s^{-1}$). An understanding of the role played by leg power during a judo bout is important, as techniques must be performed at high speed with loads consisting of the judo athlete's own weight plus their opponent (Iglesias, Fernández del Olmo, Dopico, Carratalá, & Pablos, 2000). The development of lower body power during these throws depends on the utilization of the stretch-shortening cycle (Detanico et al., 2012). This phenomenon is evident when the judo athlete executes a concentric muscle action preceded by a short eccentric phase, in which there is a pre-stretching of the muscle fibers and storage of elastic energy (during the eccentric phase), which is then reused in the concentric contraction resulting in an increase in the efficiency of the movement (Komi, 2000).

Numerous studies have investigated the effects of judo experience on balance (Barrault et al., 1991; Perrin et al., 2002; Paillard et al., 2008; Paillard et al., 2005; Yoshitomi et al, 2006; Paillard et al., 2007), postural parameters (Mesquita et al, 2002), laterality (Mikheev et al, 2002), and handgrip strength (Ache Dias et al., 2012; Leyk et al., 2007; Borges Junior et al., 2009; Franchini et al., 2005). Greater balance control in judo athletes has been observed; however, these studies investigated handgrip strength and balance in isolation. Furthermore, the understanding of the sensory information in the postural control of judo athletes has been examined while performing static or unilateral tasks rather than mimicking the specific demands of the sport. While previous studies have investigated the effects of maximal handgrip exertion on balance control, the targeted populations have primarily been non-athletes and neuropathic patients (Momiyama et al., 2006; Kato et al., 2004). However, Dias et al. (2011) examined the effect of unilateral maximal handgrip exertion on balance control in judo athletes and observed a correlation between handgrip exertion and perturbation of standing balance. Although this effect may be characterized as a balance disturbance, the perturbation appears to be related to the movements of the body performed to sustain balance while engaging in unilateral handgrip exercise (Winter, 1995; Dias et al. 2011). Furthermore, these studies have used symmetrical stance conditions, feet planted side by side, which is not entirely applicable to the demands specific to judo. Foot placement relative to hand placement influences stability of the body and provides the necessary leverage for pulling and pushing efforts (Marras & Karwowski, 1999). As a result, greater forces can be achieved when the feet are staggered, compared to a symmetrical stance, possibly due to the provision of maximal balance and leverage applied during these tasks (Marras & Karwowski, 1999).

The importance of balance control during combat while gripping, as well as the critical role of high levels of lower body power within judo provides the rationale for the purpose of the present study, which is twofold. First, to examine the effects of 10-weeks of an introductory judo course on postural control during maximal bilateral isometric handgrip testing using different stance conditions and lower body power performance. Second, to analyze the relationship between maximal bilateral handgrip exertions on postural control during varied stance conditions.

Purpose

1. To investigate the effects of 10-weeks of an introductory judo course on postural control during maximal bilateral isometric handgrip testing using different stance conditions and lower body power performance
2. To examine the relationship between maximal bilateral handgrip exertions on postural control during varied stance conditions

Hypotheses

1. Postural control during a bilateral reactionary gripping task will be altered following the 10-week introductory judo course
2. Lower body power will be increased following the 10-week introductory judo course
3. Maximal voluntary contraction will be altered when performing a staggered stance

Operational Definitions

1. Handgrip Maximal Voluntary Contraction (MVC) - The maximum force generated from both hands
2. Postural Control – The task of controlling the body's position in space for dual purposes of stability and orientation
3. Center of Pressure Amplitude (COP): the standard deviation of displacement of COP in a given direction measured during each MVC trial
4. Center of Pressure Mean Velocity: The average distance traveled by the COP over the time elapsed during each MVC trial
5. Center of Pressure Area: 95% ellipse measuring the amount of COP movement from its orientation each MVC trial
6. Anteroposterior Directions ($COP_{AP)}$: Shift in COP amplitude on the y-axis
7. Mediolateral Direction ($COP_{ML)}$: Shift in COP amplitude on the x-axis
8. Dominant Hand – Hand dominance was determined via the Waterloo Handedness Questionnaire
9. Dominant Leg – Leg dominance was determined via the Waterloo Footedness Questionnaire

Delimitations

1. Participants were healthy and free of disease or injury
2. No previous history of training in the sport of judo
3. Between the ages of 18 and 35 years old

Assumptions

1. Participants answered all questionnaires truthfully and accurately
2. Participants gave maximal effort on all testing measures
3. Participants maintained similar exercise and physical activity levels throughout the duration of the study

Limitations

1. Participants were only recruited from the University of Central Florida
2. Participants were only those who volunteer for the study
3. The introductory judo course only took place once per week, lasting a maximum length of two hours each meeting
4. Due to the amount of time between the two testing sessions, participant withdrawal from the study was a concern
5. Equipment issues prevented the analysis of certain variables
6. Diet and supplementation was not controlled

CHAPTER II: REVIEW OF LITERATURE

Analysis of maximal handgrip strength in judo

Cortell-Tormo, Pérez-Turpin, Lucus-Cuevas, Pérez Soriano, Llana Belloch, Martinez Patiño, 2013

Handgrip strength and hand dimensions in high-level inter-university judoists

The aim of this study was to evaluate the influence of anthropometric parameters in handgrip strength and sport achievement. Fifty-four judokas (22±2.83 yrs.) of the 2009 Inter-University Championship of Spain, with similar training experience (8.8±3.77 yrs.) participated in this study. Prior to testing, basic anthropometric measures were taken (height, weight, body mass index). Participants were then divided into categories by weight: (50-66kg, n = 15; 67-81kg, n = 21; > 81kg, n = 18). Maximal handgrip strength of the dominant and non-dominant hand were measured with a hand dynamometer. Hand dominance was established by asking the participant which hand was used to hold a pencil and to throw a ball. During handgrip strength testing, participants were instructed to stand comfortably with their shoulder adducted. The position of the hand remained constant, with a downward direction, not allowing the palm the flex at the wrist joint during grasping. Participants performed 3 5-second maximal voluntary contraction trails on the hand dynamometer, with the best performance of both hands used for analysis. Results indicated that there was a significant difference in maximal handgrip strength at the 50-66kg group (44.85±6.63) compared to both the 67-81kg group (50.12±7.87) and the >81kg group (54.15±7.16) ($p<0.05$). Additionally, a significant relationship was seen between maximal handgrip strength of the dominant hand and basic anthropometric variables (height, weight, BMI) ($p<0.01$). In summary, it appears that handgrip strength of judokas is likely dependent on basic anthropometric measurements.

Bonitch-Góngora, Almeida, Padial Puche, Bonitch-Domínguez, Feriche, 2013

Maximal isometric handgrip strength and endurance differences between elite and non-elite young judo athletes

The primary aim of this study was to evaluate the differences and similarities between elite and non-elite young judokas in terms of maximal isometric handgrip strength and handgrip strength endurance. Seventy-three elite and non-elite adolescent male and female judokas participated in this study. Elite participants consisted of members of the U-17 Portuguese, Swedish, and Danish national judo teams (elite: medalists in the National U-17 Championships in each country), while Non-elite participants were members of the U-17 regional team from Andalusia, Spain (non-elite: non-medalists in the National U-17 Championships in Spain). All participants had practiced judo for more than 5 years, and trained between 4 and 10 hours per week. Maximal isometric handgrip strength (MIHS) of the dominant hand was measured using a manual electronic dynamometer connected to a computer running corresponding software which monitored strength as a function of time, expressing it as the maximum and mean of that applied during each repeated test. Participants were seated in a chair, with their backs supported, feet on the floor, and elbow flexed to 90°. The dynamometer was placed on a height-adjusted table, not allowing the testing arm to be rested. Three 6 second attempts were tested, with 30 second recovery between each attempt. The highest of the three attempts was recorded as the MIHS, expressed as absolute values (N), relative to the muscle area of the testing arm (N/cm^2), and as the mean of the absolute strength over the three attempts. Time taken to reach maximal strength was recorded during it attempt. Results revealed significantly higher absolute and relative MIHS in elite females compared to non-elite females (305.6 ± 40.5 N vs. 231.0 ± 63.8 N; 12.9 ± 1.8 N/cm^2 vs. 10.2 ± 1.8 N/cm^2 for elite and non-elite respectively; $p \leq 0.01$). Elite and non-elite males displayed similar, though not significant, absolute MIHS (460.7 ± 92.3 N vs. 415.1 ± 70.9 N, respectively; $p \geq 0.05$). However, elite males exerted significantly higher relative MIHS than non-elite males (15.4 ± 1.5 N/cm^2 vs. 13.4 ± 1.6 N/cm^2; $p \leq 0.001$). Furthermore, significant differences were found between absolute ($p \leq 0.01$) and relative ($p \leq 0.01$) MIHS values for men and women. In all cases assessed, the non-elite group took significantly longer to reach MIHS ($p \leq 0.05$). A strong correlation was found between arm muscle area and MIHS ($r=0.81$, $p \leq 0.001$), as well as between forearm circumference (cm) and MIHS ($r=0.80$, $p \leq 0.001$). Intra-group analysis revealed a significant overall effect of the eight successive trials on the relative MIHS on each trial in both sexes and levels (elite and non-elite; $p \leq 0.001$). Comparative analysis of the pairs showed a decrease in relative MIHS between the first and eighth repetition of 24.5 ± 9.1% and 18.8 ± 9.1% in males and 18.4 ± 9.3% and 16.8 ± 7.0% in female, elite and non-elite respectively. Likewise, relative MIHS significantly decreased during the first two repeats in males of both groups, but only after the first repeat in elite female judokas ($p \leq 0.05$). In conclusion, this study showed significant differences between elite and non-elite female judoka's ability to exert high levels of both absolute and relative MIHS in the dominant hand, while significant differences between elite and non-elite males was only seen in regards to relative MIHS. Furthermore, although decreases in relative and mean MIHS throughout successive contraction in both sexes of both levels were observed, elite male and female judokas displayed the ability to produce greater MIHS for the duration of testing.

Denanico, Budal Arins, Dal Pupo, Dos Santos, 2012

Strength parameters in judo athletes: An approach using hand dominance and weight categories

The aim of this study were twofold; first, to relate strength parameters, judogi pull test and countermovement jump (CMJ) to body mass and body fat, and secondly, to compare the measured strength parameters from the judogi pull test between dominant and non-dominant hand strength. Eighteen trained male judokas (20.6 ± 1.8 yrs.) participated in this study. Participants came from ranging weight classifications: extra-lightweight (<69kg), half lightweight (60-66kg), lightweight (66-73kg), half middleweight (73-81kg), middleweight (81-90kg), and half heavyweight (91-100kg). All participants were in the pre-competitive phase of training. The judogi pull test assessment consisted of a pulling movement used in judo on the judogi uniform by the lapel and sleeve, simulating the *kuzushi* (unbalancing of an opponent). Participants were instructed to perform the *kuzushi*, simulating a real-time situation for five seconds using a combat group for both the right and left hands. Isometric strength with measured using a shear beam load cell connected to a signal acquisition system. Participants performed two pulling movement, to the right and left, measuring Maximal force (F_{max}), Time to maximal force (TF_{max}), Rate of force development (RFD), and Rate of peak force development (RPFD). A countermovement jump (CMJ) assessment was used to measure strength parameters of the lower body. A force plate was used to measure variables the vertical component of ground reaction forces (GRF) including: Jump height (J_{max}), Power, Maximal force (F_{max}), Rate of force development, and Peak velocity (PV). Results from the judogi pull test showed that F_{max} (absolute and relative) (478.85 ± 175.13N *vs*. 418.54 ± 126.46N, p=0.00114; 6.16 ± 1.96$N \cdot kg^{-1}$ vs. 5.41 ± 1.37 $N \cdot kg^{-1}$, p=0.0166, respectively), and RFD (939.13 ± 407.73 $N \cdot s^{-1}$ vs. 827.87 ±

396.57N·s^{-1}, p=0.0185, respectively) were significantly greater in the dominant hand whereas RPFD was significantly greater in the non-dominant hand (71.09 ± 8.72% vs. 76.12 ± 9.08%, p=0.0353, respectively).

Dias, Wentz, Külkamp, Goethel, Borges Júnior., 2012

Is handgrip strength performance better in judokas than in non-judokas?

The intent of the study was to compare the handgrip strength performance between judokas and non-judokas. Forty males, twenty-two highly trained judokas (all black belts) and eighteen non-athletes, participated in this study. Maximal isometric handgrip strength was recorded using hand dynamometer. During testing, participants were seated, feet flat on the floor, and arm at their side with their elbow flexed at 90° and forearm in the neutral position. At the onset of testing a green light would appear, prompting participants to squeeze the dynamometer as quickly as possible with maximal effort for a duration of 10 seconds. Both hands were tested, dominant followed by non-dominant. One single-trial was recorded for each hand. Results revealed that handgrip fatigue rate was significantly lower in judoka than in non-judokas. However, fatigue rate was not different between dominant and non-dominant hands. Furthermore, no effect of both group and dominance on the other parameters of handgrip strength tested (peak force, time to peak force, total impulse) were seen, nor were any significant interactions between these factors (groups and dominance) for any parameter of handgrip strength. In summary, the results of this study indicate that there was no difference in isometric handgrip strength between male high-level judokas and non-judokas, but judokas were more resistance to handgrip fatigue.

Franchini, Del Vecchio, Ferreira Julio, Matheus, Candau, 2013

Specificity of performance adaptations to periodized judo training program

The aim of this study was to monitor the changes in different variables during judo training periodization. Ten adult male judo athletes participated in this observational study. Participants were evaluated over the span of 18-weeks, first at the beginning of the preparatory phase and then again during the competition phase, one week before their main competition. Among the variables measured in this study were lower-body muscle power assessed using a countermovement jump (CMJ) and maximal isometric handgrip strength of both the right and left hand using a hand dynamometer. No significant difference was seen in CMJ when comparing pre- and post-training measurements (35.4 ± 4.2cm vs. 34.8 ± 4.1cm, respectively). Additionally, participants experienced no significant changes in maximal isometric handgrip strength after 18-weeks of training (61 ± 13kg vs. 60 ± 13kg, respectively). In summary, this study indicated that during a periodized judo program CMJ and maximal isometric handgrip strength are not improved in well trained judo athletes.

Effect of gripping on postural control

Kato, Miyamoto, Shimizu, 2004

Postural reaction during maximum grasping maneuvers using a hand dynamometer in healthy subjects

The purpose of this study was to quantitatively evaluate shifts in center of gravity (CG) during maximum grasping maneuver with a handgrip dynamometer. Twenty-six adult males, between the ages of 19-45 years, whom were all right handed, participated in this study. Postural reaction of the whole body during maximum handgrip testing was analyzed three-dimensionally using a VICON system with nine reflective placed on various locations of the body. Subjects were instructed stand with each foot on a separate force platform, keeping their feet parallel and at equal distance from each other, while grasping a dynamometer in each hand. Subjects then performed three testing sessions; Session A: Standing still holding a dynamometer in each hand. Session B: Maximum grasping maneuver using their right (dominant) hand for one or two seconds. Session C: Maximum grasping maneuver using their left (non-dominant hand). The relative location of center of gravity was calculated from the force exerted on each force platform using the equation: [left force plate (kg)/left force plate (kg) + right force plate (kg) x 100 (%)]. Results indicated that during handgrip strength testing, center of gravity shifted significantly to the grasping side ($p \leq 0.01$).

Momiyama, Kawatani, Yoshizaki, Ishihama, 2006

Dynamic movement of center of gravity with handgrip

The aim of this study was to observe the movement of center of gravity during maximal handgrip testing in young and old subjects. Twenty-one male and female subjects, with and average age of 24.3 years) took part in this study. Participants were further separated by hand dominance, left or right handed. Prior to testing, participants were instructed to stand in a comfortable position on stabilometer, grasping handgrip dynamometer in one hand. Upon the beginning of testing, center of gravity (CG) measurements were recorded before the application of grip was engaged, to serve as a control. Participants then performed three sets of 10 second maximal gripping in random order in both the dominant and non-dominant hands. Results revealed no differences in maximum handgrip strength force between the dominant and non-dominant hands. Furthermore, total CG length and total CG area significantly greater during the performance of the maximal grip than values observed while standing without grip being applied for both groups during trials performed in both the dominant and non-dominant hands. While no differences in CG length and CG area were observed between the right and left hand grip in either hand dominant subject, in the right handed group, during one of the four trials, a significant shift to the left side of the CG while gripping with the left hand was observed. Because of these findings, the authors stated the results were inconclusive and would warrant further investigation.

Dias, Külkamp, Wentz, Ovando, Borges Júnior. 2011

Effect of handgrip on the balance of judokas

The purpose of this study was to examine the effect of handgrip exertion on balance control of judo athletes. Seven young judokas (six male, one female), with a minimum of one year of judo experience, participated in this study. Participants were instructed to stand barefoot atop a stabilometric platform in a self-selected foot placement, mimicking the defensive position employed during competition. Grip testing was executed unilaterally, with the shoulder of the gripping arm adducted and flexed 90° and the elbow fully extended. The gripping arm was kept suspended in the air with his hand placed on a handgrip dynamometer, supported by a pedestal adjusted to the height of the participants shoulder. The participants were instructed to position non-gripping arm to the side of the body, elbow extended, in order to standardize the posture. During testing, participants were instructed to stand still in this position for 60 seconds with their vision focused on a target (LED - light emitting diode) set at the height of his eyes, positioned 1.5 m away. At the 30 second time point, the LED light would illuminate, prompting maximal grip to be engaged as quickly as possible, and maintained for the remaining 30 seconds of testing. This protocol was performed twice in both hands, dominant followed by non-dominant. Center of pressure (COP) was recorded from stabilometric platform simultaneously during the performance of gripping, assessing displacement amplitude (AMP), root mean squared (RMS) and average speed (VM) in the mediolateral (ML) and anteroposterior (AP) directions. As well as the elliptical area with 95% confidence (AREA). Results of this study revealed that that up to 80% of the COP variability was related to the handgrip exertion, indicating that action of performing maximal gripping generates perturbations the control of balance. However, correlations were found (r = 0.348 to 0.816) between handgrip exertion and the displacement of COP. Therefore, the authors concluded that despite the handgrip generating perturbation on participants balance control, this behavior appears to be related to the body movements performed to sustain balance, indicating a possible correlation between this anomaly.

Assessment of postural control in combat athletes

Perrin, Devinterne, Hugel, Perrot, 2002

Judo, better than dance, develops sensorimotor adaptabilities involved in balance control

The aim of this study was to analyze static and dynamic posturographic performances of high-level judoists and professional dancers to determine which sport would better improve balance control in unexpected situations. 73 healthy men and women between 20 and 35 years of age participated in this investigation. Participants were separated into three groups; ballet, judo, and control. The ballet group was made up of 14 female dancers from the Nation Ballet of Nancy and Lorraine, with 10 to 15 years of training in Classical Ballet and on-stage experience as professionals. The judo group consisted of 17 male high-level judoists, with a minimum of six years of judo experience, all involved in national and international competitions. Finally, the control group included 42 males and females with no history of participation any physical activity at a level that would be accountable for modifications in their postural control. Participants were instructed to stand barefoot atop a force platform, feet spread 10 cm apart, and their arms placed along the sides of their body. Participants were then directed to focus their vision straight ahead at a white dot positioned at eye level approximately two meters away. Two separate testing protocols (static balance, dynamic balance) for the assessment of postural control were carried out. During the static test, displacements of center of pressure (COP) were measured over 20 second periods, with the eyes open and then with the eyes closed. The collected COP data from the force platform was then used to calculate sway path, area, and anterior-posterior (AP) and lateral (Lat) oscillations. The role of visual stimulus was evaluated individually with the Romberg's quotient comparing data obtained with eyes open (EO) or closed (EC), e.g. W_{EC}/W_{EO} ratio. During the dynamic test, participants were submitted to slow rotational oscillations of the support with a 4° amplitude, at a frequency of 0.5 Hz, for 20 seconds, in both EO and EC conditions. Results of both the static and dynamic tests revealed that under the EO condition, the judo and dance groups displayed significantly greater balance regulation (sway path and area) than that of the control group. However, during the EC condition, the dance and control groups exhibited significantly worse regulation of balance (sway path and area) compared to that of the judo group. In addition, results of the lateral oscillation parameter revealed that the dance group demonstrated significantly more instability than both the judo and control groups. Furthermore, the influence of vision on balance control, the switch from EO to EC condition resulted in a significant increase of sway path, area, Lat, and AP values in all three groups, with the judo group presenting the least decrement in balance regulation. In conclusion, results of this investigation suggest that high-level athletes' present improved balance control in relation to the specific requirements of each discipline. Furthermore, due to the complex demands and dynamic nature of the practice of judo, training in the martial art leads to a greater ability to maintain postural control under various conditions than the extent observed from long-term practice of dance.

Yoshitomi, Tanaka, Duarte, Lima, Morya, Hazime, 2006

Postural responses to unexpected external perturbance in judoists of different ability levels

The purpose of this study was to examine the effect of judoist training level on postural responses of under unexpected external perturbation conditions. Thirty male participants took part in this investigation, 10 higher level judoists (brown belt) and 10 lower level judoists (green belt), and 10 recreationally active controls, with no previous judo experience. Postural regulation was assessed using a force platform measuring the displacement of standing center of pressure (COP) while an external posterior perturbance (EPP) was applied via horizontal traction employed by a fixed pulley system and a load equivalent to 6% of the participant's body weight strapped around the chest. Prior to the beginning of testing, participants were placed in the harness while standing barefoot atop the force platform and instructed to keep their eyes open. Arms were positioned along the side of the body, while participants' knees were kept straight, and feet were placed shoulder width apart. At the onset of testing, EPP was slowly applied until the load was suspended to its maximal extent. When it was concluded that the participant appeared to be adapted to the EPP, the load was then unexpectedly removed so that the capacity of balance restauration could be evaluated. This protocol was performed three times, at a duration of 30 seconds per trial. Results of this study reported that the higher level judo group presented lower COP speed than the control group, as well as gradual and continuous COP displacement pattern during balance recovery, indicating that the level of practice in the sport of judo may influence the performance of balance control.

Lower body power of combat athletes

Franchini, Del Vecchio, Ferreira Julio, Matheus, Candau, 2013

Specificity of performance adaptations to periodized judo training program

The aim of this study was to monitor the changes in different variables during judo training periodization. Ten adult male judo athletes participated in this observational study. Participants were evaluated over the span of 18-weeks, first at the beginning of the preparatory phase and then again during the competition phase, one week before their main competition. Among the variables measured assessing lower body power were countermovement jump (CMJ) and Wingate tests. No significant difference was seen in CMJ when comparing pre- and post-training measurements (35.4 ± 4.2cm vs. 34.8 ± 4.1cm, respectively). In summary, this study indicated that during a periodized judo program CMJ and maximal isometric handgrip strength are not improved in well trained judo athletes.

Buśko & Nowak, 2009

Changes in maximal muscle torque and maximal power output of the lower extremities in male judoists during training

The purpose of this study was to observe the changes in maximal power output of the lower extremities of male judo athletes during pre-competition training. Five male judo athletes of the Polish National team participated in this study. Participants performed six countermovement jumps (CMJ) and three bounce counter-movement jumps (BCMJ) atop a dynamometric platform which calculated maximal power generated during the jump as well as jump height. Testing was completed at three separate time points: pre-training, after competition of the strength training phase of training, and after pre-competition phase of training. Results revealed that CMJ power significantly decreased from the first to second measurement time point, while no changes were observed in BCMJ power or CMJ and BCMJ height. The authors concluded that pre-competition training for the sport of judo had no influence on maximal power performance of the lower body.

Kim, Jongku, Cho, Hyun-Chul, Jung, Han-Sang, Jong-Dae, 2011

Influence of performance level and anaerobic power and body composition in elite male judoists

The purpose of this investigation was to examine the relationship between body composition and anaerobic performance of elite level judoists. Male South Korean participated in this study, 10 national team members (NT), 26 university varsity members (VT), and 28 university junior varsity members (JV). The NT consisted of athletes preparing for the 2008 Beijing Olympics; the VT was made up of individuals who participated in the 2008 Beijing Olympic trials, and the JT were scheduled to compete in the contest to select athletes for the International Teenage Championship Meet. Participants warmed on the cycle ergometer for 10 minutes, were provided a 5 minute break, and then performed second warm-up lasting five minutes. Following the warm-up, participants then performed a 30-second Wingate anaerobic power test to measure peak and mean anaerobic power of the lower body. Results revealed that the peak power of the NT and VT groups were significantly greater values observed in JT group. The NT group mean power was significantly greater than those of VT and JT, while no significant difference was observed between VT group and JT group. Based on these findings, authors concluded that a greater training level in the practice of judo has the ability to improve lower body anaerobic power performance.

Kim, Lee, Trilk, Kim, Lee, Cho, 2011

Effects of sprint interval training on elite judoists

The purpose of this study was to investigate the physiological and performance changes in anaerobic fitness following sprint interval training in elite judo athletes. Twenty-nine male university level judo athletes participated in this study. All participants were Korean National Championship medalists or had practiced at the senior or junior international level for the past 12 months. Participants were assigned to either a sprint interval training group (SIT, N=11) or a control group (CG, N=18). All participants performed lower body Wingate anaerobic power tests at baseline, mid-point (4 weeks) and at the completion of the training (8 weeks). Both groups took part in the standardized winter off-season training program, consisting resistance training as well as judo practice. In addition to the standard training, the SIT group performed interval sprint training completed on a treadmill, consisting of 30 second maximal running efforts with a 4-minute warm-up period and 4 minutes of recovery between sprints. The number of sprints per training session increased from six (weeks 1, 2) to eight (weeks 3, 4) to ten (weeks 5–8). Results of study revealed that anaerobic peak power and mean power in SIT group significantly increased by 16% and 17% at 4 weeks and by 17% and 22% at 8 weeks compared to baseline values. The authors concluded that the inclusion of SIT to judo athlete’s training program has the ability to increase lower body anaerobic power.

CHAPTER III: DESIGN AND METHODOLOGY

Participants

Twenty-nine healthy men and women between the ages of 18 and 35 were recruited for this study. Participants were recruited inform the University's Beginning Judo class during the 2015 Fall semester (figure 1) or current university students, who served as controls. Before enrolling in the study, all participants completed a Confidential Medical and Activity Questionnaire as well as a Physical Activity Readiness Questionnaire (PAR-Q) to determine if they had any physical limitations or chronic illnesses that would keep them from performing exercise. Additionally, participants completed an Exercise History Questionnaire to access athletic background, and a Waterloo Handedness and Footedness Questionnaire to determine individual hand and foot dominance. Potential control subjects were required to agree to maintain their current physical activity and exercise regimen during the 10-weeks between pre- and post-testing. All participants provided inform consent before beginning the study. This study was approved by the institutional review board.

Research Design

A within-subject, repeated measures design was used to determine and evaluate the effects of 10-weeks of an introductory judo course on bilateral handgrip maximal voluntary contraction (MVC) strength, postural sway (PS), and countermovement jump (CMJ) performance. Each participant visited the Human Performance Laboratory twice, once for an initial screening and pretesting and once for a 10-week post-test. On the initial visit, an informed consent was obtained, all questionnaires were completed, anthropometrics were collected, body composition was analyzed, and participants were familiarized with the testing protocol. Once familiarization was completed, participants performed nine bilateral isometric MVC tests using three different stance conditions while standing on a portable force platform to determine baseline MVC strength and shifts in center of pressure (COP) and completed three CMJ tests on the portable force platform to assess vertical jump power and ground reaction forces of both legs. After the 10-week intervention period, participants returned to complete post-testing.

Variables

The independent variables included in this study were: (a) group [introductory judo course vs. control], (b) time [pre vs. post], (c) hand [dominant vs. non-dominant], (d) foot [dominant vs. non-dominant], and (e) stance [neutral, dominant foot forward, non-dominant foot forward]. The dependent variables included in this study were: (a) maximal voluntary contraction (MVC), (b) anteroposterior (y-axis) and mediolateral (x-axis) postural sway, (c) peak force (PKF),peak power (PP), and rate of power development (RPD) from the CMJ.

Instrumentation

- Handgrip dynamometer (Baseline Hydraulic Hand Dynamometer, Fabrication Enterprises, Inc., White Plains, NY) used to determine maximal voluntary contraction (MVC)
- Portable force platform (AccuPower, Advanced Mechanical Technology, Inc., Watertown, MA) used to ground reaction forces during the different stances and countermovement jumps (CMJ)
- A-Mode ultrasound (BodyMetrix BX-2000, IntelaMetrix Inc, Livermore, CA) and software (BodyView Professional Software IntelaMetrix Inc, Livermore, CA) used to measure body composition

Initial Screening

Prior to participation in the study, each prospective participant visited the Institute of Exercise Physiology and Wellness Human Performance Lab and provided verbal agreement to an Informed Consent Form, completed a PAR-Q, a Confidential Medical and Activity Questionnaire, Exercise History Questionnaire, and a Waterloo Footedness and Handedness Questionnaire. The participant's anthropometrics (height, weight) were measured and body composition testing was completed via three-site A-mode ultrasound measures.

Body Composition

The BodyMetrix BX2500 (IntelaMetrix, Inc., Livermore, CA) A-mode ultrasound in conjunction with Body View software was used to assess body composition measurements. The Jackson and Pollock 3-site skinfold (Jackson and Pollock, 1978, 1980) locations and equations were used to estimate body fat percentage (BF%). The sites included the chest, abdomen, and thigh of the right side of the body for males, and the triceps, suprailiac, and thigh of the right side of the body for females. Subjects were asked to remove their footwear, and stand with their right foot resting atop their left foot, as to ensure no weight was applied to the right leg during the measurement of the thigh. Measurements were made at each site by applying ultrasound transmission gel to the ultrasound probe and lightly placing the probe to the specific site. The probe was then moved back and forth over the length of ~5 mm for a duration of three to five seconds. Care was taken to control the amount of pressure applied to the probe to ensure minimal compression of skin, which would alter the thickness of the subcutaneous fat. Each site was measured approximately two to three times, based on the software's agreement between measurements, and BF% was automatically calculated from the Body View software. All A-mode measurements were performed by the same researcher and intraclass correlation coefficients ($ICC_{3,1}$) were assessed as 0.949 with a standard error of measurement (SEM) of 2.04%.

Assessment of Bilateral Reactionary Gripping Task

Maximal Voluntary Contraction Familiarization

Following the completion of all questionnaires and body composition measurements, participants who met the study criteria were familiarized with the experimental procedures. Participants were given time to get acquainted with the hydraulic handgrip (HG) dynamometers (Baseline Hydraulic Hand Dynamometer, Fabrication Enterprises, Inc., White Plains, NY) as well as perform practice trials gripping while in the various stance positions. Participants were instructed to assume the neutral stance at a comfortable width of their choice. This width was recorded and kept constant during each of the stance conditions throughout the duration of testing.

Maximal Voluntary Contraction (MVC)

Participants performed nine bilateral handgrip maximal voluntary contractions with HG dynamometers to determine handgrip peak force in kilograms (kg) of both the dominant (DOM) and non-dominant hand (NON) (Figure 2). The nine trials were assigned in a randomized fashion among three different stances (three performed with a neutral stance (N), three performed with a dominant (D) foot forward stance, and three performed with a non-dominant (ND) foot forward stance) while standing on a portable force platform (AccuPower, Advanced Mechanical Technology, Inc., Watertown, MA). Prior to each trial, participants were instructed to assume the randomly assigned stance position, at the previously establish width, with both shoulder adducted and elbows bent at a 90 degree angle while holding dynamometers in both their DOM and NON hand. Participants were directed not begin squeezing until prompted. At the beginning of each trial, participants were instructed to grasp the dynamometer as forcefully as possible for approximately five seconds without deviating from the stance specifically assigned to that trial. At the end of each trial participants were instructed to cease gripping and were provided a recovery period of 60 seconds during which they were allowed to relax from gripping position. All MVC testing was performed by the same researcher and ICCs of the D and ND hands in the N stance were assessed 0.917 (SEM: 2.39 kg) and 0.972 (SEM: 2.44 kg), respectively. The highest MVC value achieved during the three attempts for both the D and ND hands at each stance condition was used for analysis.

Assessment of Postural Control

During MVC testing, participants performed all trails while standing barefoot on a 40 x 30 x 4.9 inch portable force platform (AccuPower, Advanced Mechanical Technology, Inc., Watertown, MA) to measure changes in standing center of pressure (COP) in the anterior/posterior (AP) and mediolateral (ML) directions among the three different stance conditions (N, D, and ND) during the approximately five seconds of maximal gripping. COP data signals were filtered using a zero-phase, sixth order, Butterworth low-pass filter with a cut-off frequency of 10 Hz (Santos et al., 2008). Participants performed each stance three times, in a randomly assigned order, with 60 seconds of recovery provided between each trial. Stance width was recorded during each initial stance trial and then kept consistent throughout each subsequent trial. During post-testing trials, stance order and width were replicated to match that of pre-testing trials. COP parameters calculated from force plate signal during each stance condition were standard deviation (SD) of amplitude in the AP and ML directions, mean velocity, and area

(Moghadam et al., 2011). The COP parameters are defined in Table 1. Values for each stance condition were averaged and used for analysis.

Assessment of Lower Body Power

Countermovement Jump Familiarization

Subsequent to the completion of MVC testing, participants were instructed to put their shoes back on and then familiarized with the procedures for the CMJ testing. Participants were given time to perform practice jumps prior to the beginning of testing.

Countermovement Jump (CMJ)

Participants performed three bilateral countermovement jumps (CMJ) while standing on a portable force platform (AccuPower, Advanced Mechanical Technology, Inc., Watertown, MA) to determine peak force output (PKF) in Newtons (N), peak power output (PP) in watts (W), and rate of power development (RPD) in watts per second ($W \cdot s^{-1}$). During each of the three trials participants were instructed to jump as high as possible. Following each jump, 60 seconds recovery was provided. All CMJ testing was performed by the same researcher and ICCs of the three CMJ variables were assessed for CMJ_{PKF}, CMJ_{PP}, and CMJ_{RPD} 0.948 (SEM: 118.57 N), 0.978(SEM: 202.44 W), and 0.859 (SEM: 2199.15 $W \cdot s^{-1}$). Of the three trials, the trial resulting in the best CMJ_{PP} performance, and thus that trials corresponding CMJ_{PKF} and CMJ_{RPD}, was used for analysis.

Statistical Analyses

All data was analyzed to determine statistically significant changes and differences between trials utilizing SPSS (version 21.0). The Shapiro-Wilk test was used to analyze the normality of the MVC and COP values among the different stance conditions and the CMJ measures. A three-way mixed factorial analysis of variance (ANOVA) [time (pre, post) × stance (N, D, ND) × group (JDO, CON)] was used to assess potential interactions from pre- and post-intervention in MVC of the DOM and NON hand, separately due to dynamometers inconsistencies, during each of the three stance conditions between the JDO and CON groups. For the evaluation of COP, MV, and Area, four separate three-way mixed factorial ANOVAs [time (pre, post) × stance (N, D, ND) × group (JDO, CON) were used to assess potential interactions from pre- and post-intervention shifts in COP during the different stance conditions between the JDO and CON groups. Three separate two-way mixed factorial ANOVAs [time (pre, post) × group (JDO, CON)] were used to analyze the CMJ_{PKF}, CMJ_{PP}, and CMJ_{RPD} data during pre- and post-intervention testing. Levene's test of homogeneity of variance was completed for all MVC, COP, and CMJ values during the ANOVA. Results were considered significant at an alpha level of $p \leq 0.05$, and a confidence interval of 95% was established in all cases.

CHAPTER IV: RESULTS

Twenty participants, ten JDO and ten CON, were included in the statistical analysis. Nine participants in total, were not included in the data analysis from the original 29. Three participants (one JDO, two CON) were immediately dropped upon completion of pre-testing due to the lack of an established dominant leg according to the results the Waterloo Footedness Questionnaire. Three participants (two JDO, one CON) withdrew from participation in the study due to scheduling conflicts. One participant in the CON group sustained an injury, caused by outside physical activity prior to post-testing, and could not complete the study. Two CON participants were dropped due to missing values following data collection. Table 2 displays the mean and standard deviation (mean ± SD) values for the age, height, weight, and body fat percentage of the participants in each group.

Maximal Voluntary Contraction

Table 3 displays the mean and standard deviation (mean ± SD) values for the handgrip maximal voluntary contraction (MVC) strength testing of both the dominant and non-dominant hands among the three different stance conditions (MVC_{DOM}N, MVC_{NON}N, MVC_{DOM}D, MVC_{NON}D, MVC_{DOM},ND, MVC_{NON}ND) before and after the intervention period for the JDO and CON groups. Normal distribution of all MVC data was verified ($p>0.05$), except for pre-testing MVC_{NON}ND. Figure 3 shows the pre- and post-training MVC_{DOM} values during the N, D, and ND stance conditions for the JDO and CON groups. Figure 4 shows the pre- and post-training MVC_{NON} values during the N, D, and ND stance conditions for the JDO and CON groups.

Maximal Voluntary Contraction of the Dominant Hand

No significant time×stance×group interaction ($F_{2,36}$=0.219, *p=0.805*) was found for DOM handgrip MVC strength. Furthermore, no main effects were identified of time ($F_{1,18}$=0.147, *p=0.705*), stance ($F_{2,36}$=3.622, *p=0.059*), or group ($F_{1,18}$=1.037, *p=0.322*).

Maximal Voluntary Contraction of the Non-Dominant Hand

No significant time×stance×group interaction ($F_{2,36}$=1.301, *p=0.285*) was found for NON handgrip MVC strength. Furthermore, no main effects were identified of time ($F_{1,18}$=0.466, *p=0.504*), stance ($F_{2,36}$=1.406, *p=0.257*), or group ($F_{1,18}$=0.682, *p=0.420*).

Assessment of Postural Control

Table 4 displays the mean and standard deviation (mean ± SD) values for the center of pressure (COP) amplitude in the anteroposterior (A/P) and mediolateral (M/L) directions among the three different stance conditions (COP_{AP}N, COP_{ML}N, COP_{AP}D, COP_{ML}D, COP_{AP}ND, COP_{ML}ND) before and after the intervention period for JDO and CON groups. Table 5 displays the mean and standard deviation (mean ± SD) values for the mean velocity of COP among the three different stance conditions (MV-N, MV-D, MV-ND) before and after the intervention period for both JDO and CON groups. Table 6 displays the mean and standard deviation (mean ± SD) values for the area of COP among the three different stance conditions (Area-N, Area-D, Area-ND) before and after the intervention period for both JDO and CON groups. Normal distribution of all postural sway data was verified (*p>0.05*), except pretest COP_{ML}-N (*p≤0.001*), pretest COP_{ML}-ND (*p=0.031*), pretest MV-N (*p=0.008*), pretest Area-N (*p≤0.001*), pretest Area-D (*p=0.001*) pretest Area-ND (*p=0.012*), post-test COP_{AP}-N (*p=0.003*), post-test Area-D (*p=0.005*).

Center of Pressure Amplitude in the Anteroposterior Direction

No significant time×stance×group interaction ($F_{2,36}$=0.216, *p=0.806*) was found for COP_{AP}. Furthermore, no significant main effects were identified for time ($F_{1,18}$=1.940, *p=0.181*), stance ($F_{2,36}$=3.009, *p=0.062*), or group ($F_{1,18}$=0.259, *p=0.617*). Figure 5 shows the pre- and post-training COP_{AP}N, COP_{AP}D, and COP_{AP}ND values for the JDO and CON groups.

Center of Pressure Amplitude in the Mediolateral Direction

No significant time×stance×group interaction ($F_{2,36}$=0.480, *p=0.623*) was found for COP_{ML} amplitude. Furthermore, no significant main effects were identified for time ($F_{1,18}$=2.584, *p=0.125*) or group ($F_{1,18}$=0.516, *p=0.482*). However, there was a significant main effect for stance ($F_{2,36}$=25.097 $p \leq 0.001$). When collapsed across group and time, COP_{ML} amplitude was significantly higher in the DOM and ND foot forward stances than in the N stance. Figure 6 shows the pre- and post-training COP_{ML}N, COP_{ML}D, and COP_{ML}ND values for the JDO and CON groups.

Mean Velocity of Center of Pressure

No significant time×stance×group interaction ($F_{2,36}$=0.231, *p=0.795*) was found for COP mean velocity. Furthermore, no significant main effects were observed for time ($F_{1,18}$=3.856, *p=0.065*) or group ($F_{1,18}$=0.009, *p=0.927*). However, a significant main effect for stance was also observed ($F_{2,36}$=15.819, $p \leq 0.001$). When collapsed across group and time, mean velocity of COP was significantly higher during the DOM and ND foot forward stances then in the N stance. Figure 7 shows the pre- and post-training MV-N, MV-D, and MV-ND values for the JDO and CON groups.

Center of Pressure Area

No significant time×stance×group interaction ($F_{2,36}$=0.559, *p=0.577*) was found for COP area. Furthermore, no significant main effects were observed for time ($F_{1,18}$=2.243, *p=0.152*) or group ($F_{1,18}$=0.209, *p=0.653*). However, a significant main effect for stance was also observed ($F_{2,36}$=4.969 *p=0.012*). When collapsed across group and time, COP area was significantly larger during the ND foot forward stance than in the N (*p=0.017*); However, no significant difference was seen between the D and N (*p=0.058*) and D and ND (*p=1.000*) stances. Figure 8 shows the pre- and post-training Area-N, Area-D, and Area-ND values for the JDO and CON groups.

<u>Assessment of Lower Body Power</u>

Table 7 displays the mean and standard deviation (mean ± SD) values for CMJ peak force, peak power, and rate of power development (CMJ_{PKF}, CMJ_{PP}, CMJ_{RPD}) before and after training for both JDO and CON groups. Normal distribution of all CMJ data was verified (p>0.05).

Countermovement Jump Peak Force

No significant time×group interaction ($F_{1,18}$=0.106, *p=0.748* was found for countermovement jump peak force. Furthermore, no significant main effects were identified for time ($F_{1,18}$=1.506, p=0.235) or group ($F_{1,18}$=0.335, *p=0.570*). Figure 9 shows the pre- and post-testing CMJ_{PKF} values for the JDO and CON groups.

Countermovement Jump Peak Power

A significant time×group interaction ($F_{1,18}$=5.120, *p=0.036*) was found for countermovement jump peak power. Follow up t-test revealed that the JDO group CMJ_{PP}

significantly increased from pre (3584.70 ± 716.59 W) to post-testing (3750.10 ± 699.61 W). Although, no significant main effects were identified for time ($F_{1,18}$=1.973, *p=0.177*) or group ($F_{1,18}$=0.000, *p=0.987*). Figure 10 shows the pre- and post-testing CMJ_{PP} values for the JDO and CON groups.

Countermovement Jump Rate of Power Development

No significant time×group interaction ($F_{1,18}$=0.909, *p=0.353*) was found for countermovement jump rate of power development. Furthermore, no significant main effects were identified for time ($F_{1,18}$=0.029, *p=0.867*) or group ($F_{1,18}$=0.243 *p=0.628*). Figure 11 shows the post-testing CMJ_{RPD} values for the JDO and CON groups, respectively.

CHAPTER V: DISCUSSION

The primary finding of the current study revealed that 10-weeks of an introductory judo course did not have an effect on postural control during a bilateral reactionary gripping task under different stance conditions (N, D, ND). However, the 10-week intervention did result in significant increases in CMJ peak power performance in the judo training group compared to controls, while no change in CMJ peak force or rate of power development were observed.

Typically, studies investigating postural sway, in both clinical and performance settings, do so under quiet standing conditions, with subjects standing atop a force platform in a fixed position, arms at their sides, and vision focused on a specific target for durations ranging anywhere from 20-70 seconds (Moghadam et al., 2011; Lin et al., 2008; Perrin et al., 2002; Leong et al., 2011; Agostini et al., 2013; Santos et al., 2008). Under static conditions, balance is maintained to a greater extent with lower COP measures having been reported (i.e. COP_{AP}: 0.14 – 0.35cm; COP_{ML} 0.08 – 0.22cm; MV: 1.37 – 151 $cm \cdot s^{-1}$; Area: 1.17 – 1.54cm^2) than those in the current investigation (refer to tables 4 – 6) during the N stance condition (Perrin et al., 2002; Moghadam et al., 2011; Lin et al., 2008; Santos et al., 2008). These differences may be attributed to two factors: 1) the different stances performed and 2) the quasi-dynamic nature of the currently utilized bilateral reactionary gripping task.

The results of the present investigation revealed a significant increase in COP area during the D and ND stance conditions, compared the N stance, while performing the bilateral reactionary gripping task. While no previous literature allows for the direct comparison of results, the few available studies examining the influence of maximal gripping on balance have observed somewhat similar findings. Kato et al. (2004) investigated the measurement of center of gravity (CG) during maximal unilateral handgrip testing, via the utilization of dual force plates and a three-dimensional motion analysis system. Using a population comparable to that of the current study, the researchers observed that the CG shifted to the side that was performing the gripping task as a result of lateral flexion of the body, trunk rotation and flexion of the neck (Kato et al., 2004). Furthermore, Momiyama et al. (2006) observed an increase in CG area (derived from the analysis of COP) during unilateral handgrip testing, while Dias et al. (2011) detected an increase in COP area values in experienced judo athletes when performing maximal grip exertion unilaterally compared to values obtained during quiet standing. While the results of these investigations are comparable to those seen in the present study, it is important to emphasize that these studies examined the effects of maximal handgrip exertion unilaterally, with the gripping arm extended 180°, and were confined to the N stance condition.

While no changes were observed following the participation in 10-weeks of an introductory judo course, insight was gained into the influence of the stance conditions. The analysis of these results revealed that COP_{ML} was significantly increased when performing a D or ND foot forward stance compared to the N stance. These findings are in agreement with those reported in previous literature. During 20 seconds of quiet standing, Kirby et al. (1987) found that compared to a N stance, right and left foot forward staggered stances of increasing width (10cm, 15cm, 30cm) resulted in significant increases in COP_{ML}. This may be explained by the biomechanical differences imposed by varied stance conditions. Previous literature has reported that when positioned in a stance condition similar to that of the N stance used in the current investigation, individuals tend to distribute their weight evenly on both limbs. However, when in staggered positions, such as D or ND foot forward stances, individuals tend to load more weight on the rear leg and foot (Jonsson et al., 2005; Wang, Jordan, & Newell, 2012). This shift in the center of mass may offer an explanation as to why increased COP values are observed in staggered stance conditions, such as D and ND, compared to values recorded during N stance condition. However, the methodological differences, equipment used, and primary foci of the above mentioned studies and the current investigation do not allow for in-depth comparisons.

The results of the current study showed that 10-weeks of an introductory judo course did not alter the MVC of either the DOM or NON hand. These findings are similar to those of Franchini et al. (2015), who reported no significant changes in maximal isometric handgrip strength following 18-weeks of judo specific training in high-level judo athletes (with a minimum of five years of experience in the sport). In contrast to the training aspect of the current investigation, Franchini et al. (2015) utilized a periodized approach, consisting of 3-4 days per week of aerobic and anaerobic training in addition to combat specific simulations.

The currently observed MVC values, ranging from 22 to 61kg, are similar with previous literature reporting MVC in male and female non-judoka (Dias et al., 2012; Borges Junior et al., 2009; Schlüssell et al., 2008; Bohannon et al., 2006) and judoka (Dias et al., 2012; Leyk et al., 2007; Borges Junior et al., 2009). With respect to hand dominance, the existence of bilateral deficits is unclear (Dias et al., 2012; Franchini et al., 2005; Bontich-Góngora et al., 2012). While MVC differences between of the DOM and NON hands were unable to be assessed during the current study, a non-significant trend was seen in MVC indicating differences between stance conditions with the potential for an increase in grip strength of the DOM hand during the D stance. It should be noted that, to the extent of the authors' knowledge, all previous literature investigating maximal handgrip strength of judo athletes have done so in a unilateral manner, under varying conditions, ranging from the seated position to standing with the gripping arm fully extended 180°. Thus, the current investigation is novel in that it investigates bilateral isometric handgrip strength measured simultaneously while under different stance conditions.

Maximal grip strength is easily influenced by the posture of the individual performing the grasp. As such, there are discrepancies in the extant literature concerning the most effective method of grip strength assessment. Kikumoto et al. (1993) reported that greater force could be generated in a standing position compared to sitting due to the superior concentration on the gripping task that can be achieved while standing. Oxford (2000) reported that greater force may be applied during gripping with the elbow extended than when flexed. In contrast, Kuzala and Vargo (1992), and Ng and Fan (2001), reported that the greatest grip strength is generated with the elbow flexed, as a result of the muscle length-tension relationship, since the length of the finger flexor muscles are at their longest, allowing the production of maximum tension (Brand & Hollister, 1999; Gowitzke & Milner, 1988; Lieber, 1992).

The ability to generate maximal force during continuous gripping decreases with extended contraction time (Nicolay & Walker, 2005). Franchini et al. (2011) observed that isometric grip strength did not differ between varying levels of competition, and dynamic grip strength endurance was the discriminant factor between judo athletes of different levels of competition. Thus, it is likely that measurement of dynamic handgrip strength endurance may be more relevant to judo athletes' evaluation than the measurement of isometric maximal strength, since maximal strength is likely compromised when continuous and/or intermittent gripping is employed for extended durations, such as during judo competition or training. Future investigations should consider examining the relationship between an athletes grip endurance, potentially under varied stance conditions, following the initiation of judo training.

Vertical jump performance is not largely described in the literature with regard to judo athletes. It has been suggested that CMJ performance may be not sensitive to changes in a judo athlete's lower body power production (Callister et al., 1990). Moreover, the majority of the previous literature reported the height achieved during jump testing (squat jump or CMJ) as evidence of lower body power production (Filaire et al., 2001; Iglesias et al., 2003; Monteiro et al., 2007) rather than the direct analysis of power a with a force plate. The currently reported jumping power improvements in novice judo practitioners are in discordance to those of previous literature in trained judo athletes. Franchini et al. (2015) reported no change in CMJ performance following 18 weeks of judo specific training, while Busko and Nowak (2008) reported no change in CMJ performance across different phases of judo specific training in Polish national-level judo athletes. Thus, the divergent findings may be attributed to training-induced adaptations, since possessing a higher pre-training status has shown to limit the magnitude of increases in strength (Hakkinen et al., 1988).

Despite the discrepancy of the previous literature and the present investigation regarding vertical jump performance, increases in lower body power, measured using the Wingate test, have been observed following judo training (Franchini et al., 2015; Zaggelidis & Laxaridis, 2012). Kim et al. (2011) reported significantly higher lower-body Wingate peak power in high-level judo athletes compared to university-level athletes. Moreover, Kim et al. (2011b) also observed improvements in lower-body Wingate peak power in athletes subjected to 8 weeks of judo training and high-intensity intermittent exercise. Analysis of the demands and effects of a judo contest on lower body power are somewhat uncommon in the scientific literature. However, it is thought that a high lower body power is essential to meet the functional demands imposed by judo (Sbriccoli et al., 2007; Thomas et al., 1989). Fagerlund and Hakkinen (1991) reported that higher levels of power and force in the legs have the ability distinguish top-class judo athletes from lower levels of competition. Furthermore, CMJ performance is indicative of maximal muscle power production (Bosco et al., 1982), and estimates the ability to use the elastic energy accumulated during the stretch-shortening cycle. The findings of the present investigation, in regards to CMJ peak power production, suggest that the performance of specific judo situations possess the ability to magnify such factors.

The relatively small number of participants (n = 20) makes it difficult to detect small possible differences between the groups, and the amount of time dedicated to the practice of judo may not have been a long enough of an intervention to illicit postural adaptations. Future investigations of postural control during different stance conditions while performing bilateral reactionary gripping tasks should be examined after a longer duration and/or greater frequency of training (i.e. more than two hours once a week). Based upon the contemporary body of scientific knowledge supporting the influence of judo experience on postural regulation (Paillard, Montoya, & Dupui, 2007), similar variables should be evaluated in judo athletes with extended training backgrounds. Furthermore, the current study measured postural reaction solely while preforming the reactionary gripping task. In the future, postural measures should be additionally assessed prior to performing the gripping task to begin to wholly understand the influence of maximal bilateral gripping on postural control during varying stance conditions.

In conclusion, the results of the current investigation indicated that 10-weeks of an introductory judo course increased CMJ_{PP}; however, no effects on postural control (COP, MV, or Area) or bilateral MVC strength of the DOM and NON hand during varied stance conditions were identified. Furthermore, results revealed that bilateral MVC exertion had no influence on postural control performed during varying stance conditions. These results suggest that 10-weeks of an introductory judo course conducted once a week lasting two hours per session is not sufficient to promote the improvement of postural control while performing a bilateral reactionary gripping task or cause an increase bilateral MVC strength. Despite the lack of significant differences between stances, additional examination may be required in order to fully evaluate the potential influence of stance manipulation on grip strength. The findings of this investigation, including some insights into the relationship between handgrip exertion, postural control, and stance conditions, may be useful in the future development of a sport-specific method of assessing judo athletes.

APPENDIX A: LIST OF FIGURES

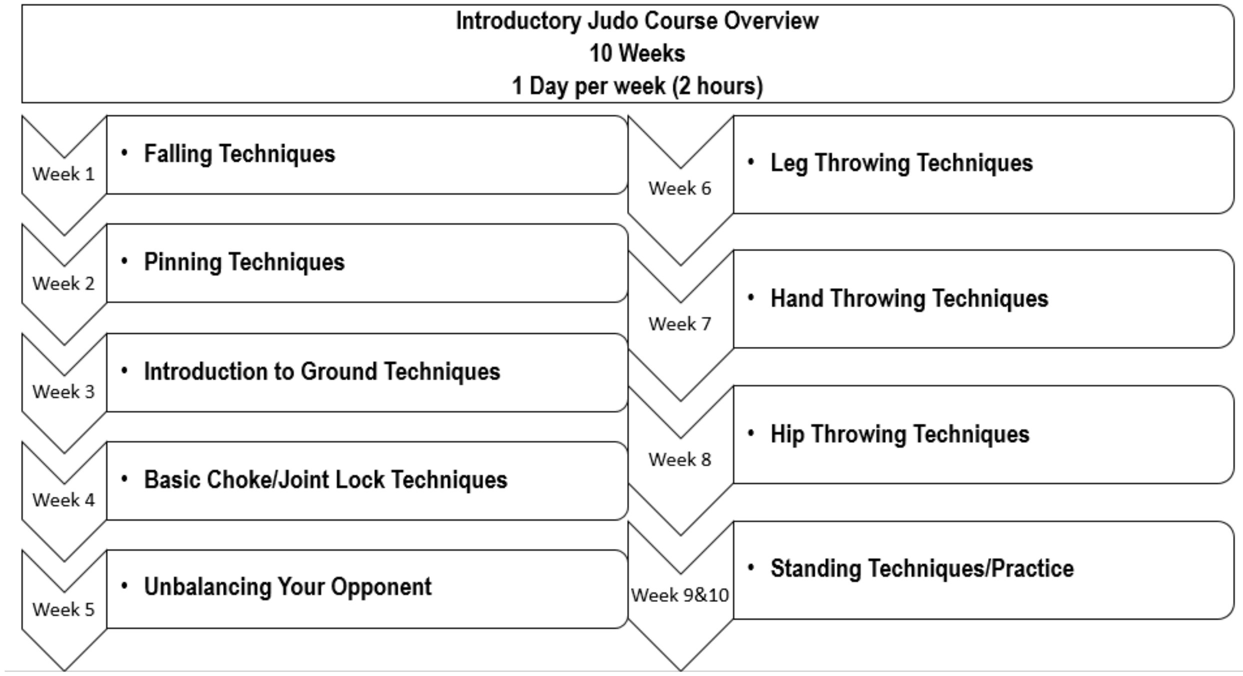


Figure 1: Overview of 10-week introductory judo course

Figure 2*:* Schematic of the foot position for the three stance conditions

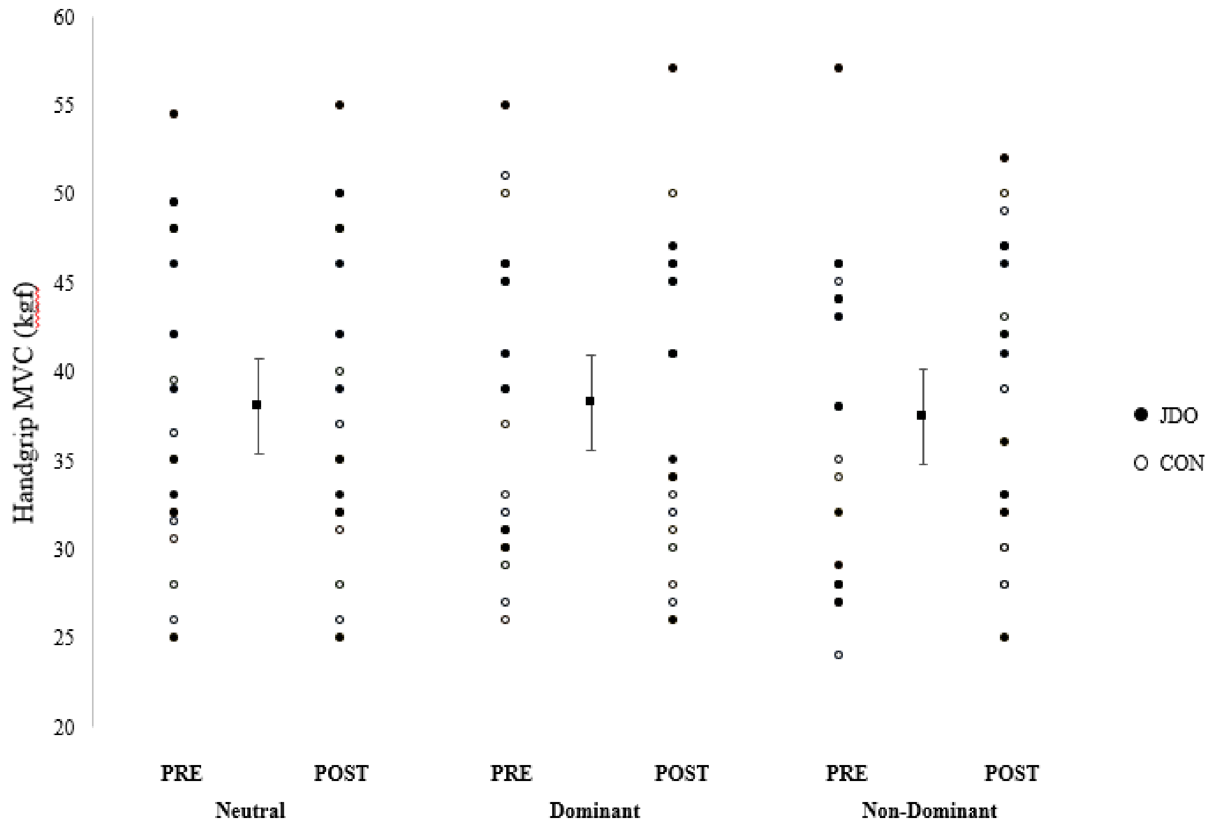


Figure 3: Maximal Voluntary Contraction of the Dominant Hand.

MVC=Maximal Voluntary Contraction; DOM=Dominant Hand; JDO=Judo group; CON=Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for MVC of the dominant hand.

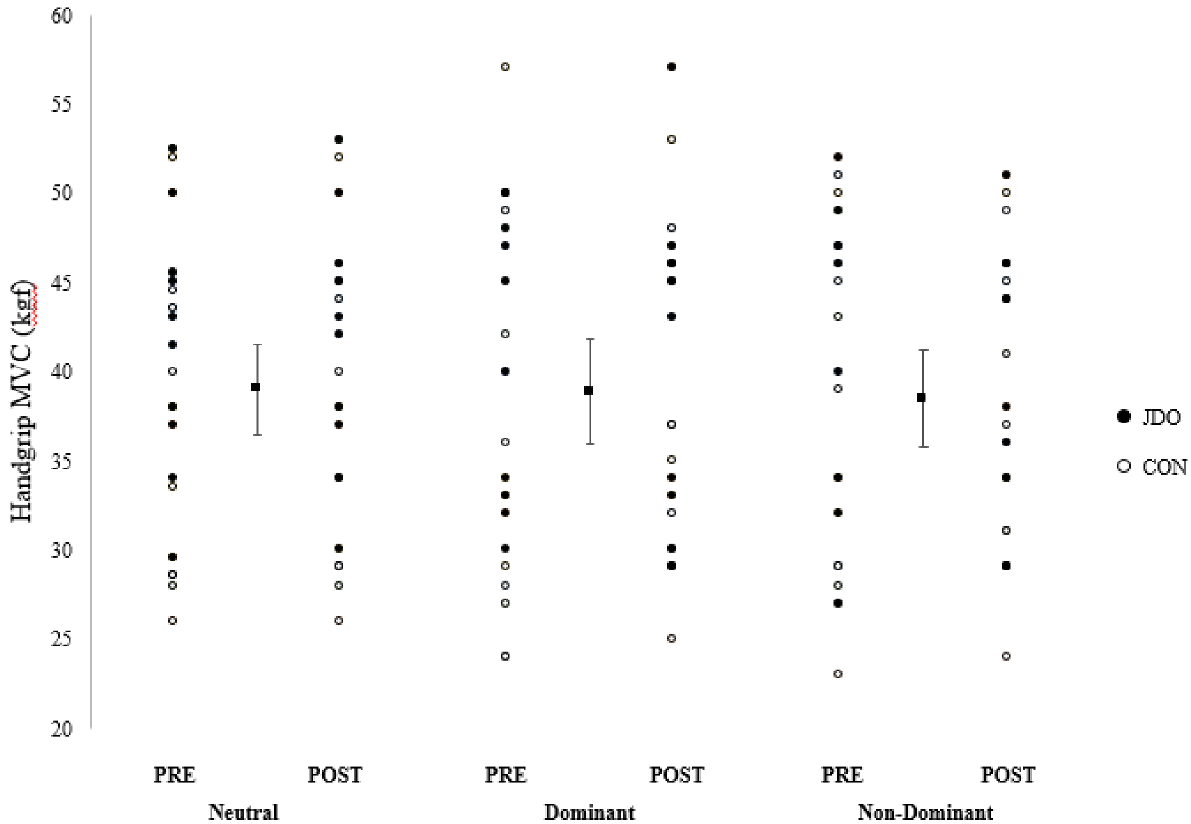


Figure 4: Maximal Voluntary Contraction of the Non-Dominant Hand.

MVC=Maximal Voluntary Contraction; NON=Non-Dominant Hand; JDO=Judo group; CON=Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for MVC of the non-dominant hand.

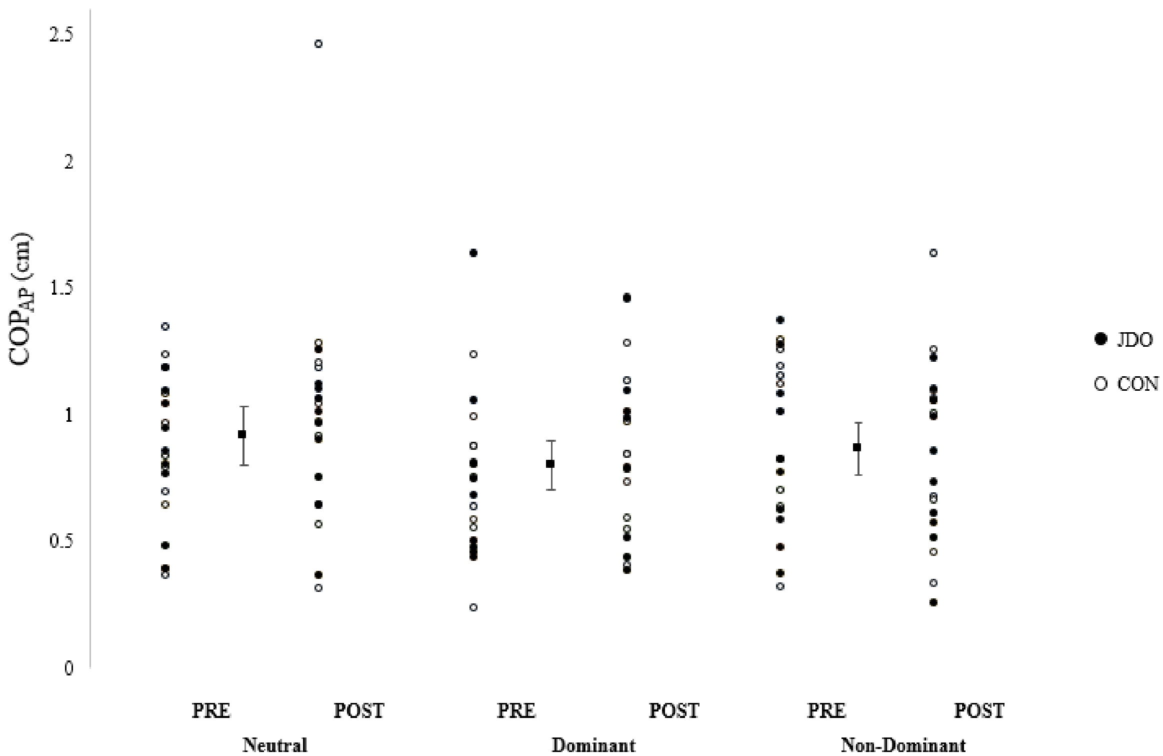


Figure 5: Center of Pressure Amplitude in the Anteroposterior Direction

COP = Center of Pressure; AP = Anteroposterior direction; JDO = Judo group; CON = Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for COP Amplitude in the anteroposterior direction.

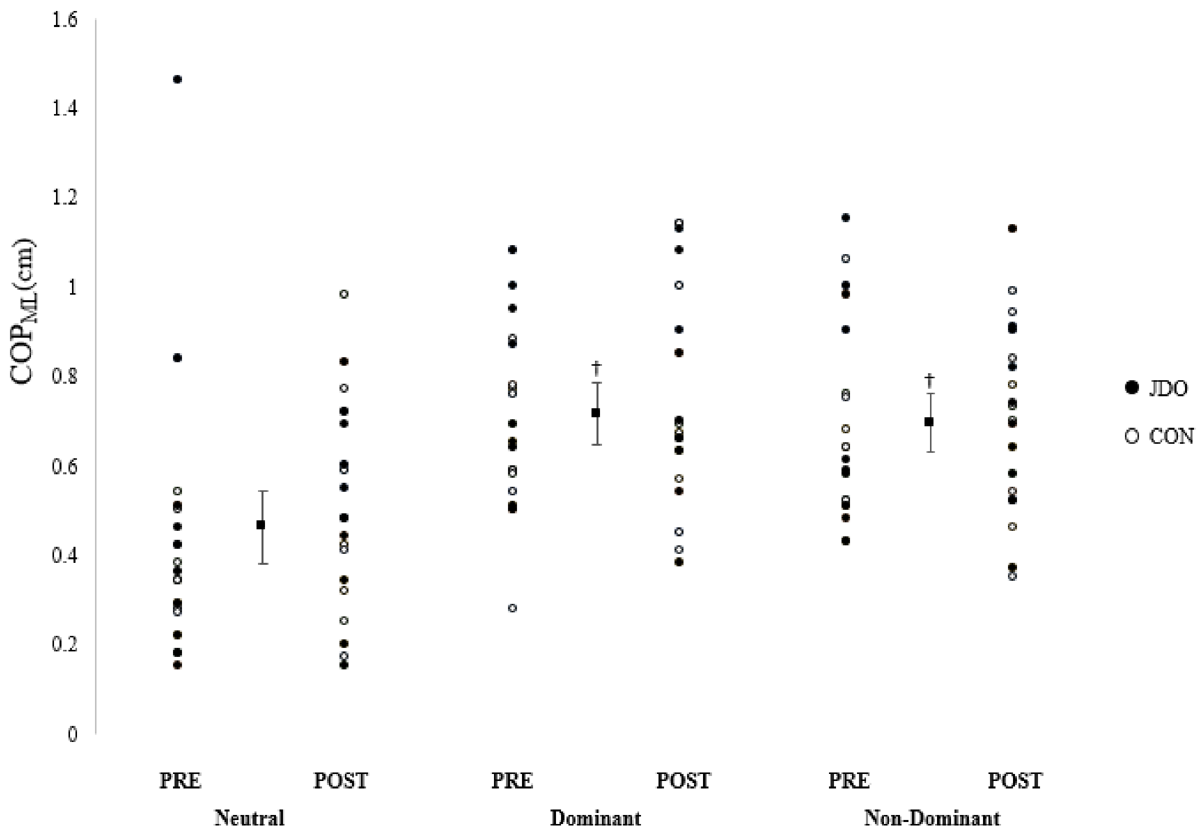


Figure 6: Center of Pressure Amplitude in the Mediolateral Direction

COP=Center of Pressure; ML=Mediolateral direction; JDO=Judo group; CON=Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for COP Amplitude in the mediolateral direction. † denotes significant difference (p<0.05) from Neutral stance.

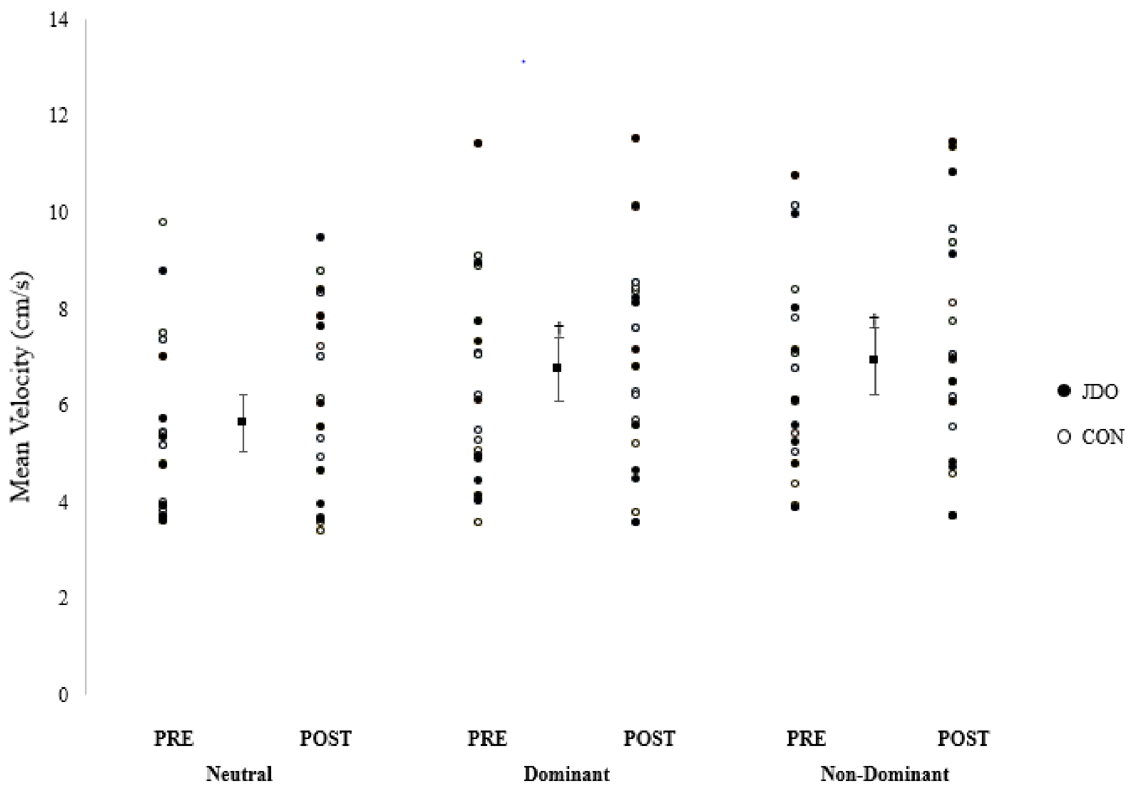


Figure 7: Center of Pressure Mean Velocity

COP=Center of Pressure; JDO=Judo group; CON=Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for COP mean velocity. † denotes significant difference (*p*<0.05) from Neutral stance.

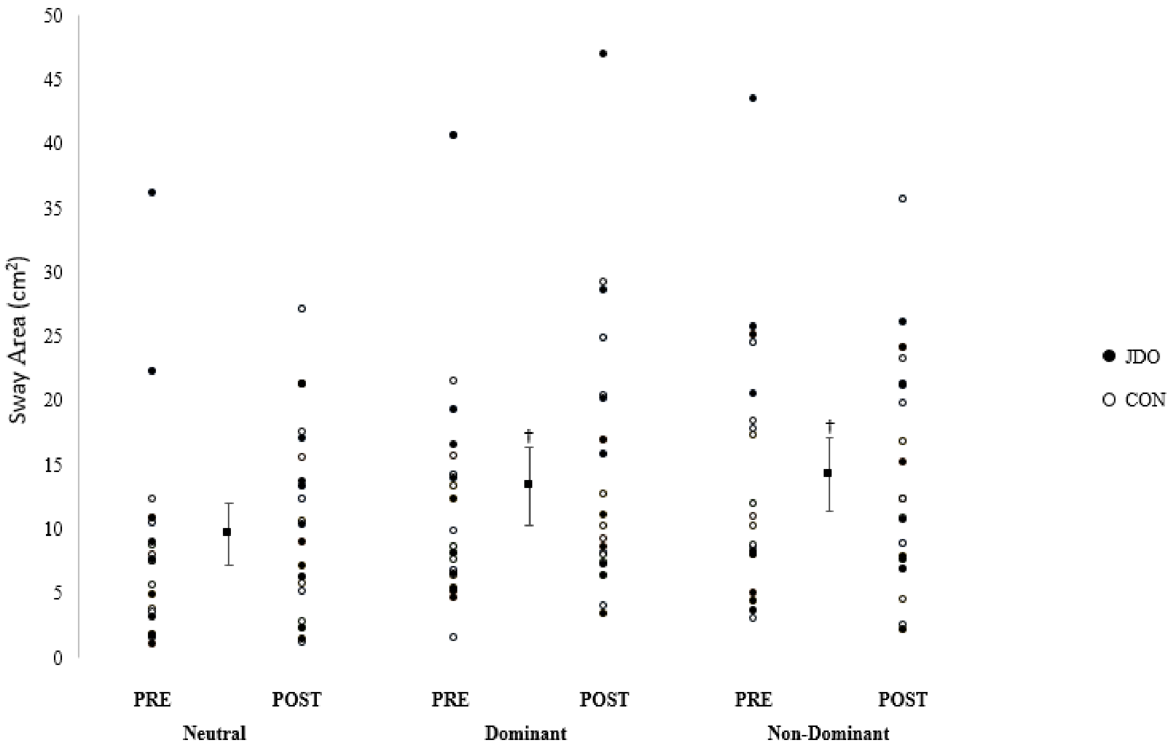


Figure 8: Center of Pressure Area

COP=Center of Pressure; JDO=Judo group; CON=Control group; Individual Judo group (black markers), Control group (white markers), and mean (black square markers) ± 95% confidence intervals (error bars) for COP area. † denotes significant difference (p<0.05) from Neutral stance.

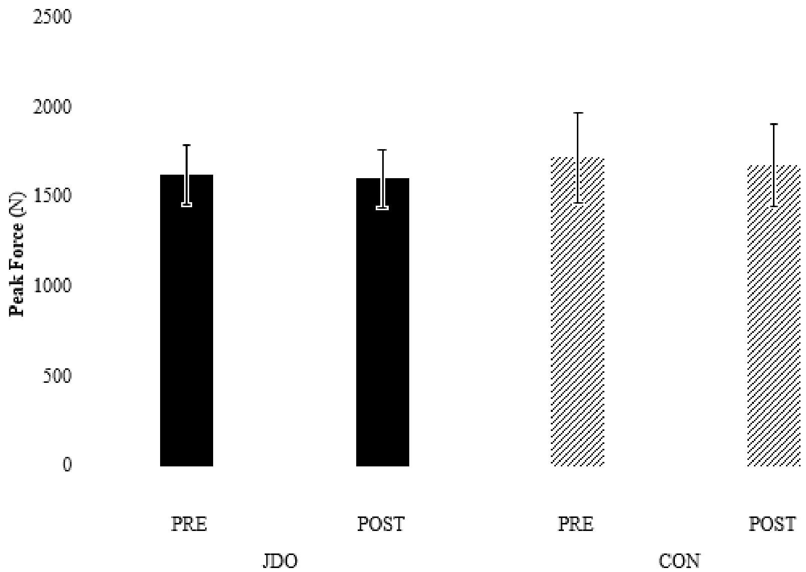


Figure 9: Countermovement Jump Peak Force

CMJ=Countermovement jump; JDO=Judo group; CON=Control group; Judo group (black bars) control group (shaded bars) mean ± 95% confidence intervals (error bars) for CMJ peak force.

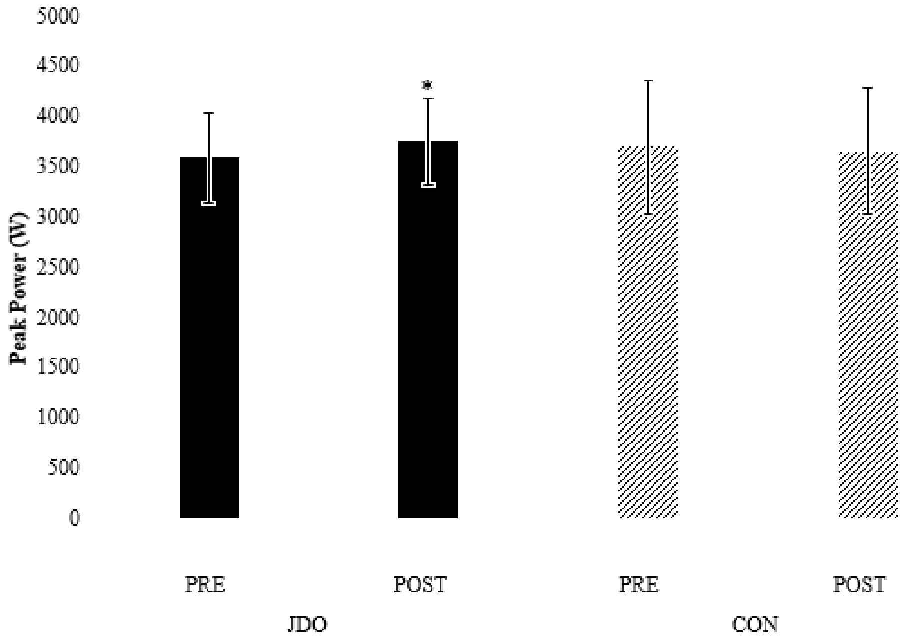


Figure 10: Countermovement Jump Peak Power

CMJ=Countermovement jump; JDO=Judo group; CON=Control group; Judo group (black bars) control group (shaded bars) mean ± 95% confidence intervals (error bars) for CMJ peak power. * denotes significant difference (*p*<0.05) from PRE.

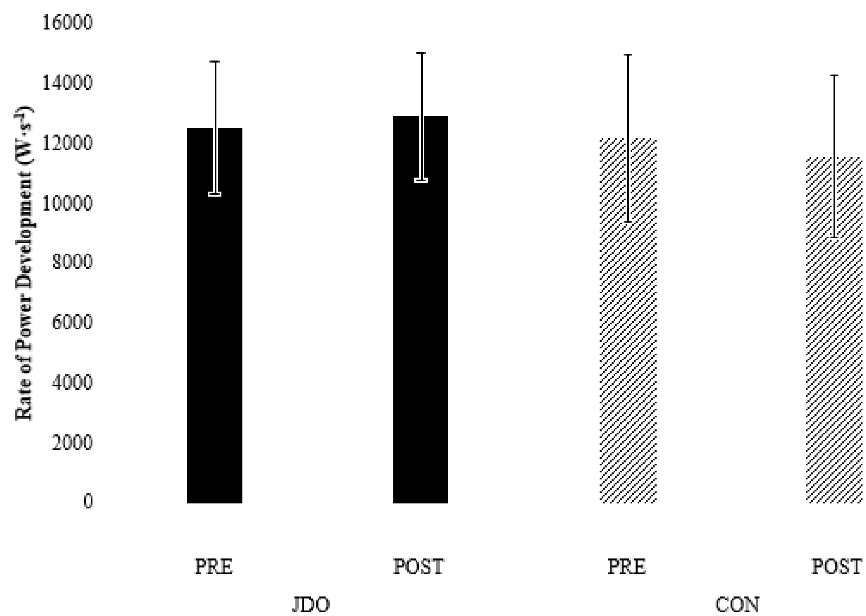


Figure 11: Countermovement Jump Rate of Power Development

CMJ=Countermovement jump; JDO=Judo group; CON=Control group; Judo group (black bars) control group (shaded bars) mean ± 95% confidence intervals (error bars) for CMJ rate of power development.

APPENDIX B: LIST OF TABLES

Table 1: Formulae for calculating the COP measures

Parameter	Formula
SD of amplitude (cm)	
AP	$\sigma_y = \sqrt{\frac{\sum(y_i - \bar{y})^2}{N-1}}$
ML	$\sigma_x = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N-1}}$
Mean Velocity (cm/s)	$\bar{v} = \frac{1}{T}\sum_{1}\sqrt{(x_{t+1} - x_t)^2 + (y_{t-1} - y_t)^2}$
Area (cm^2)	$A = 2\pi F_{0.05(2,N-2)}\sqrt{\sigma_x^2\sigma_y^2 + \sigma_{xy}^2}$ $Where\ \sigma_{xy} = \frac{(x_i - x_i)(y_i - \bar{y})}{t_{i+1} - t_i}$

COP=Center of Pressure; SD=Standard Deviation; AP = Anteroposterior direction; ML=Mediolateral direction.

Table 2: Participant PRE and POST anthropometric measures (mean ± standard deviation)

Variable	Control (*n*=10)		Judo (*n*=10)	
	PRE	**POST**	**PRE**	**POST**
Age (yrs)	21.50 ± 2.84	-	21.70 ± 3.83	-
Height (cm)	170.06 ± 8.28	-	169.91 ± 6.01	-
Body Weight (kg)	76.62 ± 12.03	76.82 ± 11.42	73.89 ± 12.10	74.40 ± 12.21
Body Fat (%)	22.41 ± 6.64	22.75 ± 5.58	19.01 ± 8.06	17.09 ± 7.47

* denotes significant difference (p<0.05) from PRE.

Table 3: Participant PRE and POST MVC of the DOM and NON hands among the three stance conditions (mean ± standard deviation)

Variable	Control (*n*=10)		Judo (*n*=10)	
	PRE	**POST**	**PRE**	**POST**
$MVC_{DOM}N$ (kg)	38.80 ± 9.33	37.90 ± 9.92	42.30 ± 8.63	41.90 ± 8.33
$MVC_{NON}N$ (kg)	40.80 ± 11.99	40.20 ± 10.46	43.00 ± 7.99	42.80 ± 7.90
$MVC_{DOM}D$ (kg)	38.00 ± 9.56	38.00 ± 10.46	41.70 ± 8.45	41.90 ± 9.36
$MVC_{NON}D$ (kg)	39.00 ± 11.77	38.00 ± 8.97	43.40 ± 8.87	42.70 ± 9.20
$MVC_{DOM}ND$ (kg)	36.10 ± 8.16	37.90 ± 9.48	40.90 ± 9.28	41.70 ± 9.13
$MVC_{NON}ND$ (kg)	39.70 ± 11.05	38.20 ± 9.20	42.50 ± 9.32	43.10 ± 7.91

MVC=Maximal Voluntary Contraction; DOM=Dominant Hand; NON=Non-Dominant Hand; N=Neutral Stance; D=Dominant Leg Forward Stance; ND=Non-Dominant Leg Forward Stance.

Table 4: Participant PRE and POST COP amplitude among the three stance conditions (mean ± standard deviation)

Variable	Control (*n*=10)		Judo (*n*=10)	
	PRE	**POST**	**PRE**	**POST**
$COP_{AP}N$ (cm)	0.91 ± 0.30	1.05 ± 0.58	0.79 ± 0.29	0.92 ± 0.26
$COP_{ML}N$ (cm)	0.35 ± 0.11	0.51 ± 0.25	0.49 ± 0.40	0.50 ± 0.22
$COP_{AP}D$ (cm)	0.75 ± 0.27	0.81 ± 0.27	0.75 ± 0.37	0.89 ± 0.38
$COP_{ML}D$ (cm)	0.64 ± 0.17	0.74 ± 0.26	0.74 ± 0.22	0.75 ± 0.23
$COP_{AP}ND$ (cm)	0.93 ± 0.32	0.92 ± 0.39	0.84 ± 0.34	0.79 ± 0.31
$COP_{ML}ND$ (cm)	0.65 ± 0.18	0.68 ± 0.21	0.72 ± 0.26	0.73 ± 0.22

N=Neutral Stance; D=Dominant Leg Forward Stance; ND=Non-Dominant Leg Forward Stance; COP=Center of Pressure Amplitude; AP=Anterior/Posterior (y-axis); ML=Mediolateral (x-axis).

Table 5: Participant pre- and post-testing postural sway mean velocity among the three stance conditions (mean ± standard deviation)

Variable	Control (n=10)		Judo (n=10)	
	PRE	**POST**	**PRE**	**POST**
MV-N (cm/s^{-1})	5.56 ± 2.05	5.82 ± 1.97	5.13 ± 1.66	6.07 ± 2.14
MV-D (cm/s^{-1})	6.65 ± 1.88	7.01 ± 1.91	6.39 ± 2.44	7.01 ± 2.56
MV-ND (cm/s^{-1})	6.48 ± 2.23	6.88 ± 1.94	6.75 ± 2.23	7.54 ± 2.93

N=Neutral Stance; D=Dominant Leg Forward Stance; ND=Non-Dominant Leg Forward Stance; MV=Mean Velocity of Center of Pressure; AP=Anterior/Posterior (y-axis); ML=Mediolateral (x-axis).

Table 6: Participant pre- and post-testing postural sway area among the three stance conditions (mean ± standard deviation)

Variable	**Control (*n*=10)**		**Judo (*n*=10)**	
	PRE	**POST**	**PRE**	**POST**
Area-N (cm^2)	6.85 ± 3.30	11.91 ± 8.50	9.80 ± 11.23	10.13 ± 6.31
Area-D (cm^2)	10.51 ± 5.69	13.37 ± 8.44	13.20 ± 10.91	16.48 ± 13.05
Area-ND (cm^2)	13.10 ± 6.24	14.65 ± 9.74	15.15 ± 13.10	14.27 ± 8.40

N=Neutral Stance; D=Dominant Leg Forward Stance; ND=Non-Dominant Leg Forward Stance.

Table 7: Participant pre- and post-testing vertical jump performance for the control and judo training groups in both the dominant and non-dominant hand and legs (mean ± standard deviation)

Variable	**Control (*n*=10)**		**Judo (*n*=10)**	
	PRE	**POST**	**PRE**	**POST**
CMJ_{PKF} (N)	1717.23 ± 407.73	1676.85 ± 364.82	1624.530 ± 268.18	1601.10 ± 256.85
CMJ_{PP} (W)	3693.10 ± 1083.77	3654.40 ± 1023.94	3584.70 ± 716.59	3750.10 ± 699.61*
CMJ_{RPD} (W/s^{-1})	12154.00 ± 4526.70	11552.90 ± 4330.90	12484.40 ± 3577.36	12903.80 ± 3432.67

* denotes significant difference (p<0.05) from PRE. CMJ=Countermovement Vertical Jump; PKF=Peak Force; PP=Peak Power; RPD=Rate of Power Development.

APPENDIX C: UCF IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Tyler William Muddle** and Co-PI: **David Fukuda**

Date: **September 02, 2015**

Dear Researcher:

On 09/02/2015 the IRB approved the following human participant research until 09/01/2016 inclusive:

Type of Review:	Submission Response for UCF Initial Review Submission Form Expedited Review
Project Title:	Effects of introductory judo training on bilateral handgrip strength, bilateral jump performance, and center of pressure with varied stances
Investigator:	Tyler William Muddle
IRB Number:	SBE-15-11505
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 09/01/2016, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Page 1 of 2

Signature applied by Patria Davis on 09/02/2015 10:12:02 AM EDT

IRB Coordinator

APPENDIX D: INFORMED CONSENT

Effects of introductory judo training on bilateral handgrip strength, bilateral jump performance, and center of pressure with varied stances

Informed Consent

Principal Investigator(s):	Tyler W.D. Muddle, B.S.
	David H. Fukuda, Ph.D.
Investigational Site(s):	University of Central Florida
	Orlando, FL 32916
	Human Performance Lab in the College of Education

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include 40 individuals at UCF. You have been asked to take part in his research study because you are a recreationally active male or female, free of any physical limitations (determined by the confidentail medical and activity history questionnaire and PAR-Q), and between the ages of 18 and 35 years old. If you agree to participate in the study and you are currently enrolled in Introductory Judo (PEM 2431), you will be included as one of the 20 volunteers in the judo training group; otherwise, and you will be included as one of the 20 volunteers in the control group. You must be willing to participate in the group to which you are assigned, in order to take part of this research study. The person doing this research is Tyler W.D. Muddle of the Institute of Exercise Physiology and Wellness at UCF. Because the researcher is a graduate student, he is being guided by Dr. David H. Fukuda, a faculty supervisor at the Institute of Exercise Physiology and Wellness.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide will not be held against you.

UCF
University of Central Florida IRB
IRB NUMBER: SBE-15-11505
IRB APPROVAL DATE: 09/02/2015
IRB EXPIRATION DATE: 09/01/2016

- Feel free to ask all the questions you want before you decide.

Purpose of the research study: The purpose of this study is to examine the effect of introductory judo training on handgrip strength, jump performance and balance.

What you will be asked to do in this study: Prior to providing verbal informed consent for study enrollment, the purpose, risks, and benefits associated with this investigation will be explained to you. Subsequently, you will be asked to complete a medical and activity history questionnaire, a physical activity readiness questionnaire (PAR-Q), an exercise history questionnaire, and a handedness and footedness questionnaire. The study protocol will require you to report to the Human Performance Lab on 2 separate occasions over the course of up to 10-weeks (initial baseline testing and ~10 weeks). During both visits, you will have height, weight, and body fat measurements taken, answer an exercise history questionnaire, complete hand-grip strength testing of the right and left hands simultaneously with hand dynamometers (handgrip measuring devices) and perform vertical jumps on a portable force platform. Additionally, you will be asked to maintain your current exercise or physical activity routine during the course of the research study.

- **Anthropometric Measurements:** height, weight, and body composition will be measure at the beginning of both visits to the lab. Body fat will be obtained using ultrasound measurements taken from seven different sites (triceps, biceps, chest, waist, thigh, hamstring, and calf).
- **Hand Grip Testing:** Hand grip testing will be performed nine times, in a randomized fashion, during each testing day. Three times with a neutral stance (feet together), three times with a right foot forward stance, and three times with a left foot forward stance, while standing on a portable force platform. You will be instructed to squeeze at maximal effort for 3-5 seconds, followed by 1-minute rest. You will be digitally recorded during each attempt.
- **Vertical Jumps Testing:** Vertical jumps will be performed nine times, in a randomized fashion, during each testing day. Three using both legs, three using only the right leg, and three using only the left leg. 1-minute rest given between each jump.

Location: All testing will be conducted in the Human Performance Laboratory within the College of Education building at the University of Central Florida,

Time required: We expect that you will be in this research study for approximately 10 weeks. You will be required to report to the Human Performance Lab on 2 separate occasions (initial baseline testing and ~10-weeks) each lasting about ~30 minutes.

Funding for this study: There is no funding for this study.

Compensation or payment: There is no compensation or other payment to you for taking part in this study.

Risks: There are no expected risks to you, the participant. However, all testing will be overseen by individuals certified in CPR and AED. You will be instructed to report any discomforts or injuries to the principal investigator, Tyler Muddle. If immediate assistance is needed it will be provided, but you must seek your own physician for medical treatment.

Cost: There is no cost to study participants.

Confidentiality: We will do our best to protect the confidentiality of the information we gather from you but we cannot guarantee 100% confidentiality. The confidentiality of records will be maintained in accordance with applicable state and federal laws. The following procedures will be used to protect the confidentiality of the data. The results of this study will be published as a group as part of a scientific publication. All information attained from the confidential medical and activity questionnaires or performance tests will be held in strict confidence. Individual results will remain confidential and only be relayed to you, the participant, upon request. All medical and activity questionnaires, as well as data collection sheets will be kept in a locked cabinet during and following the study. All information will be destroyed five years from the end of the study and not used for other research purposes. Participant folders will be marked with an I.D. number to protect against a breach of confidentiality, and the ID number will be removed upon disposal. A copy of the Informed Consent with both signature and date on it will be provided to each participant.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, talk to Dr. David Fukuda, Sport and Exercise Science (407) 823-0442 or by email at David.Fukuda@ucf.edu or Tyler Muddle, Human Performance Lab (407) 823-2367 or by email at Tyler.Muddle@ucf.edu

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study: You have the right to discontinue participation without penalty, regardless of the status of the study. Your participation in the study may also be terminated at any time by the researchers in charge of the project.

For Students and Employees of the University of Central Florida: Your participation in this study is voluntary. You are free to withdraw your consent and discontinue participation in this study at any time without prejudice or penalty. Your decision to participate or not participate in

UCF
University of Central Florida IRB
IRB NUMBER: SBE-15-11505
IRB APPROVAL DATE: 09/02/2015
IRB EXPIRATION DATE: 09/01/2016

this study will in no way affect your continued enrollment, employment, or your relationship with individuals who may have an interest in this study. _______initials

(Please note you will be participating in this study on your own time; not during regular working hours or class time.)

APPENDIX E: CONFIENTIAL MEDICAL HISTORY AND ACTIVITY QUESTIONNAIRE

Human Performance Laboratory
University of Central Florida

Confidential Medical and Activity History Questionnaire

Participant #__________

When was your last physical examination? ________________________________

1. List any medications, herbals or supplements you currently take or have taken the last month:

Medication	Reason for medication
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

2. Are you allergic to any medications? If yes, please list medications and reaction.

3. Please list any allergies, including food allergies that you may have?

4. Have you ever been hospitalized? If yes, please explain.

Year of hospitalization	Reason
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

1

5. Illnesses and other Health Issues

   List any chronic (long-term) illnesses that have caused you to seek medical care.

6. **Have you undergone major surgery within the previous 16 weeks? If yes, please explain.**

7. **Have you ever had (or do you have now) active malignant disease or cancer. If yes, please explain.**

8. **Have you ever had (or do you have scheduled) any procedure with Iodine, Barium, or Nuclear Medicine Isotopes ? (CT and PET scans are examples) If yes, please specify the date of the procedure.**

Have you ever had (or do you have now) any of the following. Please circle questions that you do not know the answer to.

Cystic fibrosis	yes	no
Water retention problems	yes	no
Epilepsy	yes	no
Convulsions	yes	no
Dizziness/fainting/unconsciousness	yes	no
Chronic headaches	yes	no
Chronic cough	yes	no
Chronic sinus problem	yes	no
High cholesterol	yes	no
Rheumatic fever	yes	no
Bronchitis	yes	no
Hepatitis	yes	no
Bladder problems	yes	no
Tuberculosis (positive skin test)	yes	no
Yellow jaundice	yes	no
Anemia	yes	no
Endotoxemia	yes	no
Hyperprolactinemia	yes	no
Anorexia nervosa	yes	no
Bulimia	yes	no
Stomach/intestinal problems	yes	no
Arthritis	yes	no
Back pain	yes	no
Gout	yes	no
Dementia	yes	no
Artificial limb	yes	no
Alzheimer's	yes	no

Have you ever had (or do you have now) any of the following. Please circle questions that you do not know the answer to.

Cardiovascular Disease	**yes**	**no**
Peripheral vascular disease	yes	no
Cerebrovascular disease	yes	no
Coronary artery disease	yes	no
Aortic stenosis	yes	no
Congestive heart failure	yes	no
Atrial fibrillation	yes	no
"Heart block"	yes	no
Myocardial infarction (Heart Attack)	yes	no
Poorly controlled hypertension	yes	no
Heart pacemaker	yes	no
High blood pressure	yes	no
Heart murmur	yes	no
Pulmonary Disease	**yes**	**no**
Chronic obstructive pulmonary disease	yes	no
Asthma	yes	no
Interstitial lung disease	yes	no
Emphysema	yes	no
Chronic respiratory disorder	yes	no
Metabolic Disease	**yes**	**no**
Diabetes mellitus (type 1, type 2)	yes	no
Diabetes insipidus	yes	no
Thyroid disorders	yes	no
Renal disease	yes	no
Liver disease	yes	no
Immunodeficiency disorder	**yes**	**no**

Any others (specify):____
____
____

Do you smoke cigarettes or use any other tobacco products?	yes	no
Do you have a history of drug or alcohol dependency?	yes	no
Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?	yes	no
Do you feel pain in your chest when you do physical activity?	yes	no
In the past month have you had chest pain when you were not doing physical activity?	yes	no
Are you ever bothered by racing of your heart?	yes	no
Do you ever notice abnormal or skipped heartbeats?	yes	no
Do you ever have any arm or jaw discomfort, nausea, or vomiting associated with cardiac symptoms?	yes	no
Do you ever have difficulty breathing?	yes	no
Do you ever experience shortness of breath?	yes	no
Do you lose your balance because of dizziness or do you ever lose consciousness?	yes	no
Have you ever had any tingling or numbness in your arms or legs?	yes	no
Has a member of your family or close relative died of heart problems or sudden death before the age of 50?	yes	no
Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?	yes	no
Do you have a bone or joint problem that could be made worse by a change in your physical activity?	yes	no

Has a health care practitioner ever denied or restricted your participation in sports for any problem yes no

If yes, please explain: ____
____

Do you know of any other reason why you should not do physical activity? yes no

Are you presently taking any nutritional supplements or ergogenic aids? (if yes, please detail. ____
____
____
____
____

I have answered these questions honestly and have provided all past and present health and exercise information to the best of my knowledge.

___________________________ ______________
Signature Date

APPENDIX F: PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ________________________________

SIGNATURE ________________________________ DATE ________________________

SIGNATURE OF PARENT ________________________ WITNESS ________________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

APPENDIX G: EXERCISE HISTORY QUESTIONNAIRE

Exercise History Questionnaire

Name: ____

Do you, or have you every participated in any type of combat sport (e.g. Karate, Wrestling, Judo, etc)? Yes No

If Yes, what type? _____________________________

How long? _________

Are you currently involved in a regular exercise program? Yes No

If Yes…

Do you engage in resistance training? Yes No

If yes, what type(s)? ________________________

How many hours per week? _________

Do you engage in aerobic exercise? Yes No

If yes, what type(s)? ________________________

How many hours per week? _________

Do you frequently compete in competitive sports? Yes No

If yes, which one(s)?

- ☐ Golf
- ☐ Bowling
- ☐ Tennis
- ☐ Track
- ☐ Swimming
- ☐ Football
- ☐ Volleyball
- ☐ Baseball
- ☐ Soccer
- ☐ Basketball
- ☐ Other:___________

Average number of times per week: _______

Exercise History Questionnaire

In which of the following high school or college athletics did you participate?

- ☐ None
- ☐ Football
- ☐ Basketball
- ☐ Baseball
- ☐ Soccer
- ☐ Track
- ☐ Swimming
- ☐ Wrestling
- ☐ Golf
- ☐ Other ____________

Please list any other forms of physical activity or exercise that you currently participate in:

____

APPENDIX H: WATERLOO HANDEDNESS AND FOOTEDNESS QUESTIONNAIRE

Waterloo Handedness Questionnaire – Revised

Instructions: Please indicate your hand preference for the following activities by circling the appropriate answer. If you ***always*** (i.e. 95% or more of the time) use one foot to perform the described activity, circle **Ra** or **La** (for **right always** or **left always**). If you ***usually*** (i.e. about 75% of the time) use one foot circle **Ru** or **Lu** (**right usually** or **left usually**) as appropriate. If you use both feet ***equally often*** (i.e. you use each hand about 50% of the time), circle **Eq**.

1.	Which hand would you use to adjust the volume knob on a radio?	La	Lu	Eq	Ru	Ra
2.	With which hand would you use a paintbrush to paint a wall?	La	Lu	Eq	Ru	Ra
3.	With which hand would you use a spoon to eat soup?	La	Lu	Eq	Ru	Ra
4.	Which hand would you use to point to something in the distance?	La	Lu	Eq	Ru	Ra
5.	Which hand would you use to throw a dart?	La	Lu	Eq	Ru	Ra
6.	With which hand would you use the eraser on the end of a pencil?	La	Lu	Eq	Ru	Ra
7.	In which hand would you use would you hold a walking stick?	La	Lu	Eq	Ru	Ra
8	With which hand would you use an iron to iron a shirt?	La	Lu	Eq	Ru	Ra
9.	Which hand would you use to draw a picture?	La	Lu	Eq	Ru	Ra
10.	In which hand would you hold a mug of coffee?	La	Lu	Eq	Ru	Ra
11.	Which hand would you use to hammer a nail?	La	Lu	Eq	Ru	Ra
12.	With which hand would you use the remote control for a TV?	La	Lu	Eq	Ru	Ra
13.	With which hand would you use a knife to cut bread?	La	Lu	Eq	Ru	Ra
14.	With which hand would you use to turn the pages of a book?	La	Lu	Eq	Ru	Ra
15.	With which hand would you use a pair of scissors to cut paper?	La	Lu	Eq	Ru	Ra
16.	Which hand would you use to erase a blackboard?	La	Lu	Eq	Ru	Ra
17.	With which hand would you use a pair of tweezers?	La	Lu	Eq	Ru	Ra
18.	Which hand would you use to pick up a book?	La	Lu	Eq	Ru	Ra
19.	Which hand would you use to carry a suitcase?	La	Lu	Eq	Ru	Ra
20.	Which hand would you use to pour a cup of coffee?	La	Lu	Eq	Ru	Ra
21.	With which hand would you use a computer mouse?	La	Lu	Eq	Ru	Ra
22.	Which hand would you use to insert a plug into an outlet?	La	Lu	Eq	Ru	Ra
23.	Which hand would you use to flip a coin?	La	Lu	Eq	Ru	Ra
24.	With which hand would you use a toothbrush to brush your teeth?	La	Lu	Eq	Ru	Ra
25.	Which hand would you use to throw a baseball?	La	Lu	Eq	Ru	Ra
26.	Which hand would you use to turn a doorknob?	La	Lu	Eq	Ru	Ra
27.	Which hand would you use for writing?	La	Lu	Eq	Ru	Ra

28.	Which hand would you use to pick up a piece of paper?	La	Lu	Eq	Ru	Ra
29.	Which hand would you use a hand saw?	La	Lu	Eq	Ru	Ra
30.	With which hand would you use to stir a liquid with a spoon?	La	Lu	Eq	Ru	Ra
31.	In which hand would you hold an open umbrella?	La	Lu	Eq	Ru	Ra
32.	In which hand would you hold a needle while sewing?	La	Lu	Eq	Ru	Ra
33.	Which hand would you use to strike a match?	La	Lu	Eq	Ru	Ra
34.	Which hand would you use to turn on a light switch?	La	Lu	Eq	Ru	Ra
35.	Which hand would you use to open a drawer?	La	Lu	Eq	Ru	Ra
36.	Which hand would you use to press buttons on a calculator?	La	Lu	Eq	Ru	Ra
37.	Is there any reason (i.e. injury) why you would have changed your hand preference for any of the above activities?	YES			NO	
38.	Have you ever been given special training or encouragement to use a particular hand for certain activities?	YES			NO	
39.	If you answered YES for either question 37 or 38, please explain:					

Waterloo Footedness Questionnaire – Revised

Instructions: Answer each of the following questions as best you can. If you ***always*** use one foot to perform the described activity, circle **Ra** or **La** (for **right always** or **left always**). If you ***usually*** use one foot circle **Ru** or **Lu** (**right usually** or **left usually**) as appropriate. If you use both feet ***equally often***, circle **Eq**.

Please do not simply circle one answer for all questions, but imagine yourself performing each activity in turn, and then mark the appropriate answer. If necessary, stop and pantomime the activity.

1.	Which foot would you use to kick a stationary ball at a target straight in front if you?	La	Lu	Eq	Ru	Ra
2.	If you had to stand on one foot, which foot would it be?	La	Lu	Eq	Ru	Ra
3.	Which foot would you use to smooth the sand at the beach?	La	Lu	Eq	Ru	Ra
4.	If you had to step up onto a chair, which foot would you place on the chair first?	La	Lu	Eq	Ru	Ra
5.	Which foot would you use to stomp on a fast-moving bug?	La	Lu	Eq	Ru	Ra
6.	If you were to balance on one foot on a railway track, which foot would you use?	La	Lu	Eq	Ru	Ra
7.	If you wanted to pick up a marble with your toes, which foot would you use?	La	Lu	Eq	Ru	Ra
8	If you had to hop on one foot, which foot would you use?	La	Lu	Eq	Ru	Ra
9.	Which foot would you use to help push a shovel into the ground?	La	Lu	Eq	Ru	Ra
10.	During relaxed standing, people initially put most of their weight on one foot, leaving the other slightly bent. Which foot do you put most of your weight one first?	La	Lu	Eq	Ru	Ra
11.	Is there any reason (i.e. injury) why you would have changed your foot preference for any of the above activities?	YES			NO	
12.	Have you ever been given special training or encouragement to use a particular foot for certain activities?	YES			NO	
13.	If you answered YES for either question 11 or 12, please explain:					

APPENDIX I: MAXIMAL VOLUNTARY CONTRACTION DATA COLLECTION SHEET

Handgrip Strength

Technician: ______________________ Date: ______________________

Subject #: ______________________

T1 T2 T3

Neutral Stance									
Peak Force	Gauge (Kg)			Raw (Volt) (Min & Max)					
	1	2	3	1		2		3	
Left Hand									
Right Hand									

Right Foot Forward Stance									
Peak Force	Gauge (Kg)			Raw (Volt) (Min & Max)					
	1	2	3	1		2		3	
Left Hand									
Right Hand									

Left Foot Forward Stance									
Peak Force	Gauge (Kg)			Raw (Volt) (Min & Max)					
	1	2	3	1		2		3	
Left Hand									
Right Hand									

Comments

APPENDIX J: COUNTERMOVEMENT JUMP DATA COLLECTION SHEET

Vertical Jump Testing

Subject #: ______________________ Date: ______________________

T1 T2 T3

Bilateral Jump			
Jump	1	2	3
PKF (N)			
PP (W)			
RPD			

Right leg Unilateral Jump			
Jump	1	2	3
PKF (N)			
PP (W)			
RPD			

Left Leg Unilateral Jump			
Jump	1	2	3
PKF (N)			
PP (W)			
RPD			

Comments

APPENDIX K: BODY COMPOSITION DATA COLLECTION SHEET

Body Composition

Subject # _______________ Technician: _____________

Date: _______________ DOB: ____________________

Weight (kg) _________________

Standing Height (cm) _____________

Sitting Height (cm) ________________

A-Mode:

Males:

Chest (mm) _____________ Waist (mm) _____________

Thigh (mm) _______________

Females:

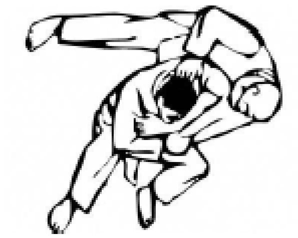
Tricep (mm) _____________ Waist (mm) _____________

Thigh (mm) _______________

APPENDIX L: RECRUITMENT FLYER

VOLUNTEERS NEEDED FOR RESEARCH STUDY

"Effects of introductory judo training on bilateral handgrip strength, bilateral jump performance, and center of pressure with varied stances"



Description of Project:

We are investigating the effects of introductory judo training on hand grip strength, balance, and jump performance

Who is Eligible?

Men and women between the ages of 18-35 enrolled in Beginning Judo (PEM 2431)

And

Men and women between the ages of 18-35 free of any physical limitations

What will you be asked to do?

Make 2 visits to the Human Performance Lab, once for initial baseline testing and again after a time span of at least 10 weeks to complete body composition measurements, hand grip strength testing, and vertical jump testing

~30 minutes total time commitment per visit

To learn more, please contact Tyler Muddle in the Human Performance Laboratory 407-823-2367, or email at humanperformance@gmail.com

REFERENCES

Aalto, H., Pyykkö, I., Ilmarinen, R., Kähkönen, E., & Starck, J. (1990). Postural stability in shooters. *Orl*, *52*(4), 232-238.

Agostini, V., Chiaramello, E., Canavese, L., Bredariol, C., & Knaflitz, M. (2013). Postural sway in volleyball players. *Human Movement Science, 32*(3), 445-456.

Asseman, F. B., Caron, O., & Crémieux, J. (2008). Are there specific conditions for which expertise in gymnastics could have an effect on postural control and performance? *Gait & Posture, 27*(1), 76-81.

Błach, W. (2005). Judo. *Wybrane Zagadnienia Treningu i Walki Sportowej.COS, Warszawa,*

Blackwell, J. R., Kornatz, K. W., & Heath, E. M. (1999). Effect of grip span on maximal grip force and fatigue of flexor digitorum superficialis. *Applied Ergonomics, 30*(5), 401-405.

Bohannon, R. W., Peolsson, A., Massy-Westropp, N., Desrosiers, J., & Bear-Lehman, J. (2006). Reference values for adult grip strength measured with a jamar dynamometer: A descriptive meta-analysis. *Physiotherapy, 92*(1), 11-15.

Bonitch-Domínguez, J., Bonitch-Góngora, J., Padial, P., & Feriche, B. (2010). Changes in peak leg power induced by successive judo bouts and their relationship to lactate production. *Journal of Sports Sciences, 28*(14), 1527-1534.

Bonitch-Gongora, J. G., Bonitch-Dominguez, J. G., Padial, P., & Feriche, B. (2012). The effect of lactate concentration on the handgrip strength during judo bouts. *Journal of Strength and*

Conditioning Research / National Strength & Conditioning Association, 26(7), 1863-1871. doi:10.1519/JSC.0b013e318238ebac [doi]

Bosco, C., Viitasalo, J., Komi, P., & Luhtanen, P. (1982). Combined effect of elastic energy and myoelectrical potentiation during stretch-shortening cycle exercise. *Acta Physiologica Scandinavica, 114*(4), 557-565.

Brand, P. W., & Hollister, A. (1999). *Clinical mechanics of the hand* Mosby Incorporated.

Browne, J., & O'Hare, N. (2000). A quality control procedure for force platforms. *Physiological Measurement, 21*(4), 515.

Buśko, K., & Nowak, A. (2008). Changes of maximal muscle torque and maximal power output of lower extremities in male judoists during training. *Human Movement, 9*(2), 111-115.

Callister, R., Callister, R. J., Fleck, S. J., & Dudley, G. A. (1990). Physiological and performance responses to overtraining in elite judo athletes. *Medicine and Science in Sports and Exercise, 22*(6), 816-824.

Calmet, M., Miarka, B., & Franchini, E. (2010). Modeling of grasps in judo contests. *International Journal of Performance Analysis in Sport, 10*(3), 229-240.

Detanico, D., Dal Pupo, J., Franchini, E., & dos Santos, S. G. (2012). Relationship of aerobic and neuromuscular indexes with specific actions in judo. *Science & Sports, 27*(1), 16-22.

Dias, J. A., Wentz, M., Külkamp, W., Mattos, D., Goethel, M., & Júnior, N. B. (2012). Is the handgrip strength performance better in judokas than in non-judokas? *Science & Sports, 27*(3), e9-e14.

Dias, J. A., Külkamp, W., Wentz, M. D., Ovando, A. C., & Borges Junior, N. G. (2011). Effect of hand grip on the balance of judokas. *Motriz: Revista De Educação Física, 17*(2), 244-251.

Fagerlund, R., & Hakkinen, H. (1991). Strength profile of finnish judoists-measurement and evaluation. *Biology of Sport, 8*(3), 143-149.

Farmosi, I. (1980). Body-composition, somatotype and some motor performance of judoists. *The Journal of Sports Medicine and Physical Fitness, 20*(4), 431-434.

Filaire, E., Maso, F., Degoutte, F., Jouanel, P., & Lac, G. (2001). Food restriction, performance, psychological state and lipid values in judo athletes. *International Journal of Sports Medicine, 22*(6), 454-459.

Franchini, E., & Sterkowicz, S. (2000). Techniques used by judoists during the world and olympic tournaments 1995–1999. *Human Movement, 2*(2), 24-332.

Franchini, E., Takito, M. Y., Nakamura, F. Y., Matsushigue, K. A., & Kiss, M. P. D. (2003). Effects of recovery type after a judo combat on blood lactate removal and on performance in an intermittent anaerobic task. *Journal of Sports Medicine and Physical Fitness, 43*(4), 424.

Franchini, E., Takito, M., Kiss, M., & Strerkowicz, S. (2005). Physical fitness and anthropometrical differences between elite and non-elite judo players. *Biology of Sport, 22*(4), 315.

Franchini, E., Bertuzzi, R., Degaki, E., Mello, F., Fiebig, E., & Silva, W. (2008). Energy expenditure in different judo throwing techniques. *Bio-Mechanics and Sports Engineering, 2*, 55-60.

Franchini, E., Del Vecchio, F. B., Matsushigue, K. A., & Artioli, G. G. (2011). Physiological profiles of elite judo athletes. *Sports Medicine, 41*(2), 147-166.

Franchini, E., Del Vecchio, F., Julio, U. F., Matheus, L., & Candau, R. (2015). Specificity of performance adaptations to a periodized judo training program. *Revista Andaluza De Medicina Del Deporte, 8*(2), 67-72.

Franchini, E., Miarka, B., Matheus, L., & Vecchio, F. B. D. (2011). Endurance in judogi grip strength tests: Comparison between elite and non-elite judo players. *Archives of Budo, 7*(1), 1-4.

Franchini, E., Takito, M. Y., & Bertuzzi, R. (2005). Morphological, physiological and technical variables in high-level college judoists. *Archives of Budo, 1*(1), 1-7.

Fry, A. C., Ciroslan, D., Fry, M. D., LeRoux, C. D., Schilling, B. K., & Chiu, L. Z. (2006). Anthropometric and performance variables discriminating elite american junior men weightlifters. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 20*(4), 861-866. doi:R-18355 [pii]

Fukuda, D. H., Stout, J. R., Kendall, K. L., Smith, A. E., Wray, M. E., & Hetrick, R. P. (2013). The effects of tournament preparation on anthropometric and sport-specific performance measures in youth judo athletes. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 27*(2), 331-339. doi:10.1519/JSC.0b013e31825423b3 [doi]

Goldie, P. A., Bach, T. M., & Evans, O. M. (1989). Force platform measures for evaluating postural control: Reliability and validity. *Archives of Physical Medicine and Rehabilitation, 70*(7), 510-517.

Golomer, E., Crémieux, J., Dupui, P., Isableu, B., & Ohlmann, T. (1999). Visual contribution to self-induced body sway frequencies and visual perception of male professional dancers. *Neuroscience Letters, 267*(3), 189-192.

Gowitzke, B. A., & Milner, M. (1988). *Scientific bases of human movement* Williams & Wilkins.

Hakkinen, K., Pakarinen, A., Alen, M., Kauhanen, H., & Komi, P. V. (1988). Neuromuscular and hormonal adaptations in athletes to strength training in two years. *Journal of Applied Physiology (Bethesda, Md.: 1985), 65*(6), 2406-2412.

Iglesias, E., Clavel, I., Dopico, J., & Tuimil, J. (2003). Acute effect of the specific effort of judo on different strength manifestations and their relation with the reached cardiac frequency during the confrontation. rendimientodeportivo. com, 6 [digital journal]. *Rendimientodeportivo.Com, 6*

Iglesias, E., Fernández del Olmo, M., Dopico, J., Carratalá, V., & Pablos, C. Propuesta de organización y control del entrenamiento de fuerza del judoca. Paper presented at the

Jackson, A. S., & Pollock, M. L. (1978). Generalized equations for predicting body density of men. *British Journal of Nutrition, 40*(03), 497-504.

Jackson, A. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine and Science in Sports and Exercise, 12*(3), 175-181.

Junior, N. G. B., Domenech, S. C., Dias, J. A., da Silva, Affonso Celso Kulevicz, & Junior, Y. S. (2009). Comparative study of maximum isometric grip strength in different sports. *Brazilian Journal of Kinanthropometry and Human Performance, 11*(3), 292-298.

Karwowski, W., & Marras, W. S. (1998). *The occupational ergonomics handbook* Crc Press.

Kato, T., Miyamoto, K., & Shimizu, K. (2004). Postural reaction during maximum grasping maneuvers using a hand dynamometer in healthy subjects. *Gait & Posture, 20*(2), 189-195.

Kikumoto, T., Itoh, S., Suzuki, H., Sarasina, N., Sirato, K., & Hoshi, F. (1993). The influence of position difference on grip strength. *Hokkaido Phys Ther, 10*, 50-52.

Kim, J., Cho, H. C., Jung, H. S., & Yoon, J. D. (2011). Influence of performance level on anaerobic power and body composition in elite male judoists. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 25*(5), 1346-1354. doi:10.1519/JSC.0b013e3181d6d97c [doi]

Kim, J., Cho, H. C., Jung, H. S., & Yoon, J. D. (2011). Influence of performance level on anaerobic power and body composition in elite male judoists. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 25*(5), 1346-1354. doi:10.1519/JSC.0b013e3181d6d97c [doi]

Kirby, R., Price, N., & MacLeod, D. (1987). The influence of foot position on standing balance. *Journal of Biomechanics, 20*(4), 423-427.

Kuzala, E. A., & Vargo, M. C. (1992). The relationship between elbow position and grip strength. *American Journal of Occupational Therapy, 46*(6), 509-512.

Leong, H., Fu, S. N., Ng, G. Y., & Tsang, W. W. (2011). Low-level taekwondo practitioners have better somatosensory organisation in standing balance than sedentary people. *European Journal of Applied Physiology, 111*(8), 1787-1793.

Leyk, D., Gorges, W., Ridder, D., Wunderlich, M., Rüther, T., Sievert, A., et al. (2007). Hand-grip strength of young men, women and highly trained female athletes. *European Journal of Applied Physiology, 99*(4), 415-421.

Lieber, R. L. (1992). *Skeletal muscle structure and function: Implications for rehabilitation and sports medicine* Williams & Wilkins.

Lin, D., Seol, H., Nussbaum, M. A., & Madigan, M. L. (2008). Reliability of COP-based postural sway measures and age-related differences. *Gait & Posture, 28*(2), 337-342.

Little, N. G. (1991). Physical performance attributes of junior and senior women, juvenile, junior, and senior men judokas. *The Journal of Sports Medicine and Physical Fitness*, *31*(4), 510-520.

Marcon, G., Franchini, E., Jardim, J. R., & Barros Neto, T. L. (2010). Structural analysis of action and time in sports: Judo. *Journal of Quantitative Analysis in Sports*, *6*(4)

Massion, J. (1994). Postural control system. *Current Opinion in Neurobiology, 4*(6), 877-887.

Mesure, S., & Cremieux, J. (1992). The effect of judo training on postural control assessed by accelerometry. Paper presented at the *Proceeding of the X Th International Symposium on Disorders of Posture and Gait. New York: Stuttgart*, pp. 302-306.

Miarka, B., Panissa, V. L. G., Julio, U. F., Del Vecchio, F. B., Calmet, M., & Franchini, E. (2012). A comparison of time-motion performance between age groups in judo matches. *Journal of Sports Sciences, 30*(9), 899-905.

Mikheev, M., Mohr, C., Afanasiev, S., Landis, T., & Thut, G. (2002). Motor control and cerebral hemispheric specialization in highly qualified judo wrestlers. *Neuropsychologia*, *40*(8), 1209-1219.

Moghadam, M., Ashayeri, H., Salavati, M., Sarafzadeh, J., Taghipoor, K. D., Saeedi, A., et al. (2011). Reliability of center of pressure measures of postural stability in healthy older adults: Effects of postural task difficulty and cognitive load. *Gait & Posture, 33*(4), 651-655.

Momiyama, H., Kawatani, M., Yoshizaki, K., & Ishihama, H. (2006). Dynamic movement of center of gravity with hand grip. *Biomedical Research, 27*(2), 55-60.

Monteiro, L., García, J., & Carratalá, V. (2007). The strength and power in judo: Characteristics male and female. Paper presented at the *Annals of the 5th International Judo Federation World Research Symposium,* pp. 58.

Ng, G. Y., & Fan, A. C. (2001). Does elbow position affect strength and reproducibility of power grip measurements? *Physiotherapy, 87*(2), 68-72.

Nicolay, C. W., & Walker, A. L. (2005). Grip strength and endurance: Influences of anthropometric variation, hand dominance, and gender. *International Journal of Industrial Ergonomics, 35*(7), 605-618.

Nishime, R. S. (2007). Martial arts sports medicine: Current issues and competition event coverage. *Current Sports Medicine Reports, 6*(3), 162-169.

Paillard, T., Costes-Salon, M., Lafont, C., & Dupui, P. (2002). Posturokinetic activities and falls of judoist. *Science and Sports, 17*(3), 140-142.

Paillard, T., Montoya, R., & Dupui, P. (2005). Influence of postural regulation in male judokas'direction of falls 1. *Perceptual and Motor Skills, 101*(3), 885-890.

Paillard, T., Montoya, R., & Dupui, P. (2007). Postural adaptations specific to preferred throwing techniques practiced by competition-level judoists. *Journal of Electromyography and Kinesiology, 17*(2), 241-244.

Paillard, T., Costes-Salon, C., Lafont, C., & Dupui, P. (2002). Are there differences in postural regulation according to the level of competition in judoists? *British Journal of Sports Medicine, 36*(4), 304-305.

Palmieri, R., Ingersoll, C., Stone, M., & Krause, B. (2002). Center-of-pressure parameters used in the assessment of postural control. *Journal of Sport Rehabilitation, 11*(1), 51-66.

Perrin, P., Deviterne, D., Hugel, F., & Perrot, C. (2002). Judo, better than dance, develops sensorimotor adaptabilities involved in balance control. *Gait & Posture, 15*(2), 187-194.

Perrin, P., Schneider, D., Deviterne, D., Perrot, C., & Constantinescu, L. (1998). Training improves the adaptation to changing visual conditions in maintaining human posture control in a test of sinusoidal oscillation of the support. *Neuroscience Letters, 245*(3), 155-158.

Perrot, C., Deviterne, D., & Perrin, P. (1998). Influence of training on postural and motor control in a combative sport. *Journal of Human Movement Studies, 35*(3), 119-136.

Santos, B. R., Delisle, A., Larivière, C., Plamondon, A., & Imbeau, D. (2008). Reliability of centre of pressure summary measures of postural steadiness in healthy young adults. *Gait & Posture, 27*(3), 408-415.

Sbriccoli, P., Bazzucchi, I., Di Mario, A., Marzattinocci, G., & Felici, F. (2007). Assessment of maximal cardiorespiratory performance and muscle power in the italian olympic judoka. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 21*(3), 738-744. doi:R-20245 [pii]

Schlüssel, M. M., dos Anjos, L. A., de Vasconcellos, Maurício Teixeira Leite, & Kac, G. (2008). Reference values of handgrip dynamometry of healthy adults: A population-based study. *Clinical Nutrition, 27*(4), 601-607.

Shumway-Cook, A., & Woollacott, M. H. (1995). *Motor control: Theory and practical applications* Lippincott Williams & Wilkins.

Shyamal, K., & Yadav, K. M. (2009). An association of hand grip strength with some anthropometric variables in indian cricket players. *Facta Universitatis-Series: Physical Education and Sport, 7*(2), 113-123.

Sterkowicz, S., Lech, G., Jaworski, J., & Ambrozy, T. (2012). Coordination motor abilities of judo contestants at different age. *Journal of Combat Sports and Martial Arts, 1*, 5-10.

Thomas, S. G., Cox, M. H., LeGal, Y. M., Verde, T. J., & Smith, H. K. (1989). Physiological profiles of the canadian national judo team. *Canadian Journal of Sport Sciences = Journal Canadien Des Sciences Du Sport, 14*(3), 142-147.

Visnapuu, M., & Jurimae, T. (2007). Handgrip strength and hand dimensions in young handball and basketball players. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association, 21*(3), 923-929. doi:1064-8011-21-3-923 [pii]

Vuillerme, N., Teasdale, N., & Nougier, V. (2001). The effect of expertise in gymnastics on proprioceptive sensory integration in human subjects. *Neuroscience Letters, 311*(2), 73-76.

Winter, D. A. (1995). Human balance and posture control during standing and walking. *Gait & Posture, 3*(4), 193-214.

Winter, D. A. (1995). Human balance and posture control during standing and walking. *Gait & Posture*, *3*(4), 193-214.

Winter, D. A., Patla, A. E., & Frank, J. S. (1990). Assessment of balance control in humans. *Med Prog Technol*, *16*(1-2), 31-51.

Yoshitomi, S. K., Tanaka, C., Duarte, M., Lima, F., Morya, E., & Hazime, F. (2006). Postural responses to unexpected external perturbance in judoists of different ability levels. *Revista Brasileira De Medicina do Esporte*, *12*(3), 159-163.

Zaggelidis, G., & Lazaridis, S. (2013). Muscle activation profiles of lower extremities in different throwing techniques and in jumping performance in elite and novice Greek judo athletes. *Journal of Human Kinetics, 37*(1), 63-70.