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SHORT-TERM HAND-HELD VIBRATION TRAINING BENEFITS HANDGRIP STRENGTH IN COMPETITIVE JUDOKAS

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ABSTRACT

Handgrip strength (HGS) is fundamental in judo as judokas hold their opponent's judogi (uniform) throughout a contest. Therefore, maximising HGS in this specialist population is crucial to successful performance. Judokas have traditionally performed grip curl exercises to improve HGS. While recent research has investigated hand-held vibration training (HHVT) as an ergogenic aid this research is limited and to date there have been no studies assessing the efficacy of HHVT in judo. Following institutional ethics approval, 12 male competitive judokas (age mean 22 ± 8years, mass mean 81 ± 18kg, height mean 1.73 ± 0.43m) were randomly assigned to either a HHVT (n=6) or control (n=6) group. Judokas in the HHVT group were exposed to three bouts of vibration, on each hand, twice a week for a four-week period. Frequency and training time were consistent with the overload training principle. Control group performed the same isometric contractions with no vibratory stimulus. Throughout the study, both groups continued with their usual training. Prior to commencement, and following completion, of the study all judokas had their HGS measured using a handgrip dynamometer. Repeated measures ANOVA revealed a significant improvement ($P<0.001$) over time in the pre and post HGS of both conditions combined and a significant improvement ($P=0.023$) in the HGS of the HHVT condition. No significant effects ($P>0.05$) were found in regard to handedness. Judokas should therefore consider incorporating HHVT into their training regimes. However, future research should further investigate optimal exposure frequencies and training durations for HHVT in a judo population.

Keywords: judo, vibration, handgrip, strength, grip, judoka

INTRODUCTION

Judo is believed to have originated from Japan in the late 19th Century and is now firmly established as a modern martial art and popular Olympic discipline (Ohlenkamp, 2006). While described as an intermittent sport, judo contests usually incorporate short periods (20-30s) of high intensity activity (Detanico et al., 2012; Miarka et al., 2012; Zaggelidis, 2016). To be successful in judo a judoka (also referred to as a judoist or judo player) requires technique, tactics and a high level of physical fitness (Franchini, Artioli and Brito, 2013). Specific physical requisites for attaining a high performance level in judo have been identified as low body fat, high arm circumference, aerobic and anaerobic capacity and upper and lower limb strength (Ali et al. 2010; Kubo et al. 2006; Franchini et al, 2011a; Lahart and Robinson, 2015; Obminski et al. 2015). Kajmovic et al. (2014) describe that the initial contact between two judokas is through the gripping of an opponent's uniform, collectively called a judogi, comprising of a jacket (uwagi), trousers (shitabaki) and belt (obi). Consequently, the forearms and fingers are the areas most reported by judokas as needing to apply the greatest effort (Franchini et al, 2011b; Kons et al. 2018). A judoka's ability to execute effective gripping techniques, known as *kumi-kata*, is widely viewed as a key factor for success in judo competition (Bonitch-Gongora *et al*. 2013; Courel *et al*. 2014). Handgrip strength (HGS), defined as the maximal power of forceful voluntary flexion of all fingers under normal biokinetic conditions (Gandhi, Koley and Sandhu, 2010), has historically been considered fundamentally important to the judoka as it improves their ability to correctly execute a variety of throwing techniques (Courel *et al*. 2014; Silva *et al*. 2011).

Previous research has attempted to quantify and identify variations in HGS based on a range of variables: level of performance, age, sex, weight category, and hand dominance. Bonitch-Gongora et al. (2013) and Franchini et al. (2005) both reported an increased HGS in elite compared to non-elite performers and Leyk et al. (2007) found differences between judokas and non-judokas. Furthermore, Zaggelidis (2016) reported that judokas have significantly greater HGS than athletes from other martial arts, such as karate. In contrast, Ache Dias et al. (2012) reported that performance level did not influence HGS; although they did find that the higher the level of competition the greater resistance a judoka had to hand-grip fatigue. Dimare et al. (2016) highlights a reduction in HGS of master's age judokas compared to younger competitors; a trend that is also evident in the general aging population (Turusheva et al., 2017). There is consensus that males generally exhibit greater HGS than females (Leyk et al. 2007) and this is reflected in judo with male judokas having considerably higher HGS than their female counterparts (Aoki and Demura, 2008). There is also evidence of correlations between maximal force and weight category in judokas, with those in higher weight categories exhibiting higher levels of force production (Detanico et al., 2012). Differences between dominant and non-dominant hands have also been observed with the majority reporting the dominant side having considerably greater HGS (Bonitch-Gongora *et al*. 2013; Morales et al. 2014; Papacosta et al. 2013), maximal force and rate of force development (Detanico et al., 2012). Franchini et al (2005) described average HGS values of 51 kg for the dominant hand and 49 kg for the non-dominant hand while, similarly, Obminski et al (2015) reported values of 51.8 kg and 48.2 kg for the dominant and non-dominant hands respectively. However, this discrepancy is not universally accepted as others have found similarities in HGS in dominant and non-dominant hands (Ache Dias et al., 2012; Franchini, Takito and Bertuzzir, 2005).

While, traditionally, HGS training for the judoka has focused on exercises such as wrist curls, gripper work, and by employing supplemental resistance exercises (e.g. towel pull-ups) and multi- joint, judo-specific, strength training (Lahart and Robinson, 2015), recent research has indicated a need for specific training to target HGS (Kons et al. 2018). However, Obminski *et al*. (2015) state that excessive repetition of specific judo drills such as *randori* (free-style practice) and *kakari-gaiko* (continuous attack practice), performed at maximum intensity, may have detrimental effects on HGS; reportedly resulting from the accumulation of micro-injuries or chronic fatigue of muscles and tendons. While not specifically linked to the issues raised by Obminski et al (2015), and most likely fuelled from a need to gain advantages in grip techniques in a variety of disciplines, more novel training techniques have emerged relatively recently. Chang et al. (2010) found that applying kinesio-taping to the forearm had no effect on HGS but did enhance force sense. In contrast, Lens et al (2015) reported augmentation of HGS up to 48hours post-application of kinesio-taping. However, that these studies were not judo-specific, combined with an apparent lack of agreement in findings, make any generalisations difficult. Botelho and Andrade (2012) investigated the use of chiropractic cervical spine manipulative therapy (SMT) on national level judo athletes. They found that SMT initiated an overall improvement of ~12.5% in HGS compared to no enhancement in their control group. Despite vibrations traditionally being associated with negative effects on the human body (Hawkey, Rittweger and Rubin, 2016) and those specifically from hand-held tools being linked to irreversible hand injuries (Heaver *et al*. 2011), some studies have investigated the effect of whole body vibration training (WBVT) and hand-held vibration training (HHVT). While there is significant evidence that WBVT can benefit athletic performance enhancement, especially movements that utilise lower body power, in a range of sports performers (Hawkey and Morrison, 2017; Perez-Turpin et al. 2014) there is a distinct lack of empirical data on the efficacy of both WBVT and HHVT on HGS performance. While some research has reported increased electromyography (EMG) activity with the application of vibration (Hazell et al. 2007; Marin *et al.* 2012; Gómez-Cabello *et al.* 2012; McBride *et al.* 2004; Mischi and Cardinale, 2009) others have found that during press up exercises the increased EMG did not result in any kinematic changes, such as duration, posture and range of motion (Robbins et al (2014). Some studies have reported enhanced joint position sense (Tripp et al., 2009; Faust et al., 2013), and observed improved coordination (Erman, 2015) following exposure to HHVT. However, none of the studies employing vibration training (WBVT or HHVT) found increases in HGS following vibration exposure (Torvinen et al, 2002; Cochrane and Stannard; 2005; Gomez et al, 2013). Also, none of the aforementioned WBVT or HHVT studies utilised judokas as participants in their research.

Therefore, due to the importance of HGS to the judoka, the continual need for training to enhance the gripping action of the judogi, and in the absence of research specifically investigating the effect of vibration training in a judo environment, the current study was designed to assess the effects of a four-week HHVT intervention on the HGS of a competitive judoka population.

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METHODS

Following institutional ethics approval, and in accordance with the Helsinki declaration (World Medical Association, 2013), 12 male competitive judokas (age mean 22 ± 8years, mass mean 81 ± 18kg, height mean 1.73 ± 0.43m) attending a national judo centre of excellence were randomly assigned to either a HHVT or control group. The vibration training was conducted twice weekly during a four-week pre-competition training camp. Participants in the HHVT group were exposed to three bouts of vibration, on each hand, via a NEMES Bosco HHVT system. Judokas were required to stand in their usual stance posture (*Shisel*) with arms flexed 90^{o} at the elbow. A one-minute recovery period was adhered to between each bout in accordance with American College of Sports Medicine (ACSM) guidelines (Ratamess et al., 2009). Frequency and training time were consistent with the overload training principle (Ingham, 2007): 35Hz for 60s in week one, 35Hz for 70s in week two, 45Hz for 60s in week three, 45Hz for 70s in week four. The control group performed the same isometric contractions, using the same HHVT system, with no vibratory stimulus. Throughout the duration of the study, both groups continued with their usual training regime, which was controlled by coaching staff from the judo centre. Prior to the commencement, and following completion, of the study all judokas had their HGS measured using a handgrip dynamometer (Takei, Tokyo), which was adjusted accordingly for the hand size of each judoka in accordance with Watanabe et al. (2005). To ensure replication of a more natural position for judo demands than standard HGS tests, all judokas followed testing guidelines for HGS in accordance with Botelho and Andrade (2012), requiring them to stand in *Shisel* with arms flexed 90^{o} at the elbow. This procedure was conducted with the dominant and non-dominant hands in a randomised order. All trials were recorded to the nearest 0.1 kg in accordance with Watanabe et al. (2005). To allow for sufficient recovery, HGS performance in both the control and HHVT groups was assessed 72 hours following the last training session (McLester et al. 2003). This was also consistent with observations from Obminski *et al*. (2015) who reported that a minimum of two days rest was required after intensive judo training sessions to allow full recovery of HGS performance. Also, to avoid the confounding influence of circadian variation, testing was conducted at a similar time of day (± 1 hr.) as the pre-intervention testing (Teo et al. 2011).

Data analysis

A repeated measures ANOVA was used to assess any significant differences between the pre- and post- HGS performance of both the HHVT and control groups and assess any differences in hand dominance. An alpha value of $P \leq 0.05$ was used for all tests. All statistical data was performed with the statistical package for social sciences version 20.0 (SPSS, Guildford, England). All data in text, tables and figures are presented as mean ± *SD*.

RESULTS

There was no significant difference ($P = 0.92$) between the baseline overall HGS of the control (44 ± 6.6 kg) and HHVT (44.5 ± 6.5 kg) groups. Results of the repeated measures ANOVA revealed a significant effect of time ($P < 0.001$) with overall (HHVT and control combined) baseline HGS of 44.3 ± 6.6 kg increasing to 51.4 ± 8.2 kg post the four-week study (Figure 1). There was also a significant time x intervention effect ($P = 0.023$) due to the improvements in HGS of the HHVT group over the four-week

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intervention (from 44.5 ± 6.5 kg to 54.8 ± 7.4 kg) being significantly greater than improvements in the control group's HGS (44 ± 6.6 kg to 48 ± 7.7 kg) (Figure 1). There was a trend for HGS to increase across all conditions and handedness over time. Specifically, dominant HGS in the HHVT group increased from 46.3 ± 6.1 kg to 58.2 ± 6.6 kg, while the HHVT non-dominant hand HGS increased from 42.7 ± 7.1 kg to 51.5 ± 7.1 kg. In the control group, HGS of the dominant hand increased from 46.3 ± 8.1 kg to 50.2 ± 8.8 kg, while the control non-dominant hand HGS increased from 42.1 ± 5.5 kg to 45.8 ± 6.7 kg. However, despite the apparent improvements in HGS in relation to handedness, none of these changes were found to be statistically significant ($P > 0.05$) (Figure 2).

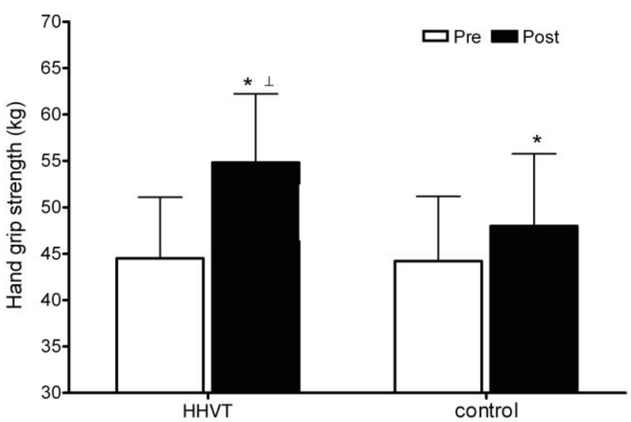

Figure 1. Results of repeated measures ANOVA showing significant effect of time and time vs. intervention. * Indicates $P<0.001$ between pre and post HGS for each group, while ⊥ indicates $P=0.023$ for intervention vs. control.

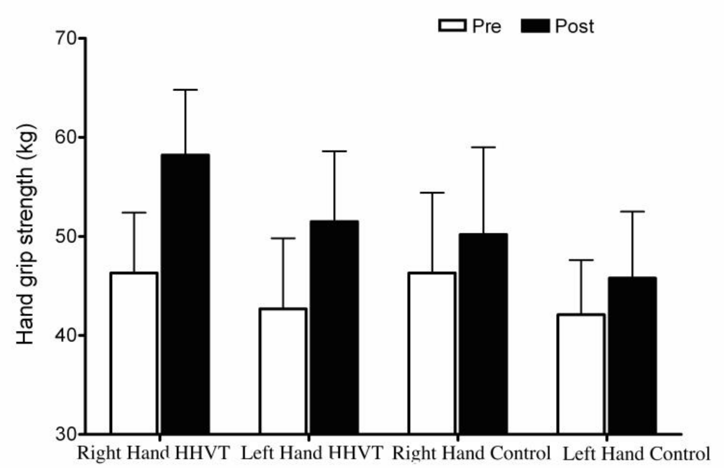

Figure 2. Results of repeated measures ANOVA showing non-significant effect of all analysis relating to handedness (P>0.05).

DISCUSSION

It is well documented that isometric handgrip strength is especially important in judo since the majority of offensive actions, especially throws or immobilisation of an opponent, require strong gripping of the judogi (Obminski et al., 2015). Consequently, the judoka with the stronger grip and more extensive grip knowledge has been described as having the advantage in a judo contest (Ohlenkamp, 2006). Maximising the gripping performance of a judoka has therefore become one of the main priorities of judo training. Indeed, maintaining optimum levels of neuromuscular performance with specific exercises designed to enhance the gripping action on the judogi has been identified by Kons et al. (2018) as of the utmost importance to the judoka. Traditionally, judokas have used exercises such as wrist curls, gripper work, and supplemental resistance exercises to improve HGS (Lahart and Robinson, 2015). Although not yet established in a judo population, the concept of hand-held vibration training (HHVT) has been investigated as a potential method of improving HGS and other factors related to performance. There is some evidence that HHVT can benefit certain aspects of functionality, such as joint position sense and coordination (Tripp et al., 2009; Faust et al., 2013, Erman 2015), but there is a lack of conclusive evidence regarding its effectiveness in enhancing HGS and currently no studies have investigated this training modality in a judo population. This current study, therefore, is the first to investigate the effects of a short-term HHVT training intervention on HGS in judokas.

The four-week training programme resulted in a significant effect for HGS in both conditions meaning there was a significant time effect ($P < 0.001$). However, the main finding of the current study is that HHVT combined with traditional judo training induces a significantly greater performance enhancing effect on HGS in a judoka population than traditional judo training alone. This is illustrated by the control group improving their overall HGS by ~8% during the four-week study compared to the ~23% overall increase in HGS seen in the HHVT group ($P = 0.23$). These results appear to demonstrate that while traditional judo training does have a performance enhancing effect on HGS, which is to be expected given the type of exercises that are performed, the additional stimulus provided by HHVT exhibits this to an even greater extent.

That the current study's findings do not concur with those of Torvinen et al (2002), Cochrane and Stannard (2005), and Gomez et al (2013) is most likely due to methodological differences. Dissimilarity in experimental protocols, the equipment used for both testing and training, and the variation in performance level of participants have all been previously suggested as factors potentially influencing results (Hawkey, 2012). Torvinen et al (2002) found no significant difference in HGS following two and four months respectively of WBVT, which could be expected as the vibratory stimulus was not applied directly to the arms and hands. When Cochrane and Stannard (2005) applied acute vibration (via a press up position on the platform) no improvement in HGS was reported. This could also be expected as no grip action was initiated; this can be related back to the lack of specificity in the application of the intervention as grip action, by definition, involves the flexion of all fingers (Gandhi, Koley and Sandhu, 2010). The lack of improvement in the Cochrane and Stannard (2005) study could also be linked to Cardinale and Wakelin (2005) who reported that optimal positioning is required in order to facilitate performance enhancement. That Cochrane and Stannard (2005) did see improvements in other performance indicators (such as jump height) also reinforces this assumption. However, this explanation is not applicable to the findings of a study by Gomez et al (2013) who also found no increase in HGS following an acute 1-hour bout of hand-arm vibration exposure. While the vibration was applied through gripping handles connected to a vibrating device in this study, and therefore transferred directly to the target location, the frequency was very low (7.5Hz); this may not have been sufficient to affect any changes in HGS performance. This can potentially be connected back to findings by Faust et al. (2013) and Tripp et al. (2015) who reported an enhanced level of joint positioning sense following HHVT at 15Hz but *not* at 5Hz; suggesting that lower frequencies are not capable of affecting any beneficial neuromuscular changes.

A secondary objective of the current study was to investigate any differences in handedness. Previous research has reported differences between dominant and non-dominant hands, although these findings have been not conclusive, with some reporting the dominant side having considerably greater HGS (Bonitch-Gongora *et al*. 2013; Morales et al. 2014; Papacosta et al. 2013; Franchini et al. 2005; Obminski et al. 2015) while others have found similarities in HGS in dominant and non-dominant hands (Ache Dias et al., 2012; Franchini, Takito and Bertuzzir, 2005). The current study found no significant difference ($P > 0.05$) between the initial HGS in each hand and no significant effects throughout the study, either in regard to condition or time.

It would appear from the results of the current study that a four-week HHVT intervention, combined with normal judo training, is sufficient to induce greater improvements in HGS than normal judo training in isolation. With previous research demonstrating that WBVT can successfully supplement training without causing any negative effects (Wyon, Guinan and Hawkey, 2010), the results of this current study appear to support the inclusion of a short-term HHVT intervention into judokas training regimes to specifically enhance HGS. However, further investigation is now required to ascertain optimal exposure frequencies and training durations for HHVT in this specialist population. Also, while every attempt was made to control certain variables within the study there are a number of limitations that must be acknowledged. While the current study ensured that all judokas undertook the training intervention (both HHVT and control groups) as supplementary to their usual training regime, coordinated by coaching staff accordingly, and received the same recovery periods, there was no control over any extra training undertaken by individual judokas. While it is not possible to rule out that this confounding influence equilibrated across groups, the lessened improvement in the control group does at least lend support to the notion that the greater performance changes were largely attributable to HHVT.

Also, the current study only investigated maximum HGS, while some previous research has highlighted that maximum-repeated HGS and resistance to fatigue (Ache-Dias et al. 2012) might also be of crucial importance to judokas' performance. Additionally, while the measurement of HGS using a handgrip dynamometer is an established technique and used extensively in judo research, Cortell-Tormo (2013) has previously identified the need for a specific grip test for judokas, which involves gripping the judogi rather than a dynamometer. This concept is supported by Kajmovic et al (2014) who stated that a handgrip test may not be an appropriate representation of gripping actions in judo; suggesting that a towel pull or equivalent may be more task specific. Heinisch et al (2013) have recently developed a new prototype system, which they report allows reliable, continuous measurement of grip strength performance at the sleeve or lapel of the judogi. Therefore, subject to validation and availability of the technique, it would be advisable to utilise such developments in any future testing of HGS in a judo population.

CONCLUSION

Results of the current study suggest that a four-week HHVT intervention when combined with traditional judo training improves the grip strength of competitive judokas to a greater extent than judo training alone. Judokas are therefore encouraged to incorporate HHVT into their training regimes. Further research is now needed in order to establish the optimum frequency and duration of stimulus in order to find the most advantageous protocol for maximising HGS in a judo population. Assessing the effectiveness of HHVT in isolation (i.e. against gripper work and hand curls) would also allow direct comparison against these current and more established training techniques. Finally, the utilisation of other methods of assessing HGS, such as a specific grip-pull test designed exclusively for judokas, may also enhance the ecological validity of any findings, as the technique may be more representative of the gripping actions performed during competition.

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