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KINESIOLOGY

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Isokinetic strength of the wrist in male aikido athletes

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Abstract

Background. Physiological research in general on aikido is scarce. Although many aikido techniques use extreme wrist flexion and extension that may lead to injury, no information is available on isokinetic strength of the upper extremities in aikido. Investigations on grip strength in martial arts and combat sports were mainly done in judo.

Aim. The purpose of the current study was to assess isokinetic strength of the wrist in recreational aikido athletes.

Material and Methods. Male aikido practitioners (n=13, 33.23±7.94 years, 180.62±8.03 cm, 80.31±13.10 kg) were recruited from a summer camp organized at Masaryk University. Subjects were tested on a Cybex Humac Norm at 120°, 180° and 240°/sec on both left and right wrists. A 3-way (Side x Movement x Angular Velocity) Anova with repeated measures on the second and third factors was used to assess the differences between right and left wrist extension and flexion by angular velocity. The level of significance for all analyses was set to an effect size of 0.20.

Results. There was a Movement x Angular velocity interaction (partial eta^2 = 0.859, 95% CI: 0.451– 0.954). Simple effects analysis showed that wrist extension at 240°/sec (13.27 ± 3.18 Nm) was lower than wrist flexion (23.55 ± 6.66 Nm) at the same angular velocity (d = 2.050, 95% CI: 0.123 – 3.978) but the effect was not clear. Flexion at 120°/sec (31.64 ± 8.06 Nm) was higher than at 180°/s (28.50 ± 7.10 Nm) but the effect was also not clear: d = 0.430 (95% CI: -2.375 – 3.235).

Conclusions. Based on the current results, strength exercises for wrist extension in aikido athletes may be indicated, although a larger sample size will be needed to arrive at a definitive conclusion. More research is required with aikidokas varying in age and experience. Female practitioners should be investigated as well. Future research should also include the positions at peak torque. Aikidokas have weaker handgrip strength than other combat sports/martial arts athletes. Based on the current results, strength exercises for wrist extension in aikido athletes may be indicated, especially when using weapons, where extension is more important in hand techniques.

Introduction

Research on physiological dimensions of combat sports is typically done on aerobic and anaerobic endurance. Initially, studies were concerned with characterizing recreational and elite combat sport athletes. Some of the earliest of these investigations were about heart rate and blood lactate in karatekas [Imamura *et al.*, 1997] as well as isokinetic leg strength in American recreational [Pieter *et al.*, 1989] and elite taekwondo athletes [Conkel *et al.*, 1988]. As expected, Pieter *et al.* [1989] reported the quadriceps to elicit higher absolute peak torquesthan the hamstrings at all angular velocities tested in American male university students. Conkel *et al.* [1988] found isokinetic strength during leg extension at the knee jointat 300°/sec to be related to force of the front (r = 0.47, 95% CI: 0.02 – 0.76) and spinning back kicks (r = 0.69, 95% CI: 0.34 – 0.87) in a combined sample of male and female members of the US national taekwondo teams. However, the relationship was not clear for the front kick, which may be related to it not being used in competition, even at the early stages of full-contact taekwondo according to the rules of the World Taekwondo Federation.

The right hamstrings to quadriceps (H/Q) peak torque ratio at 120°/s in American college students practicing taekwondo was higher when compared to a control group consisting of their counterparts in tennis (79.63 ± 15.36% vs. 53.62 ± 10.47%, d = 2.137, 9% CI: -4.237 – 8.512) but the effect was not clear [Pieter *et al.*, 1989]. Recent research has also focused on isokinetic strength of the lower extremities in taekwondo [e.g., Fong *et al.*, 2013] and karate [Probst *et al.*, 2007]. A significant correlation between isokinetic leg extension strength at 240°/sec and length of taekwondo training (r = 0.639) was reported by Fong *et al.* [2013]. Although not mentioned by the authors, the accuracy of the correlation point estimate seems to indicate that the relationship was not as strong as suggested (95% CI: 0.274 – 0.843). This is especially true for leg flexion at the knee joint at the same angular velocity (r = 0.472, 95% CI: 0.037 – 0.757) with 22.23% (95% CI: 4.01 – 40.45) overlap between isokinetic leg strength and the length of taekwondo training.

Based on the p-value, a combined sample of American male and female university karate athletes recorded a higher peak torque for the left hamstrings at 60°/sec (113.2 ± 24.2 Nm) compared to their control counterparts (101.3 ± 32.2 Nm) but the effect for the pairwise comparison was not clear (d = 0.421, 95% CI: -10.895 – 11.737). Peak torque for the right quadriceps of the karateka (115.2 ± 25.6 Nm) at 180°/sec was significantly higher, according to the p-value, than that of their control counterparts (110.3± 35.3 Nm) [Probst *et al.*, 2007] but the effect was also not conclusive (d = 0.159, 95% CI: -12.142 – 12.460).

[Drapsin *et al.* 2010] assessed isokinetic arm extension and flexion strength in male judoka.Without presenting any statistical evidence, the authors reported isokinetic strength during arm flexion to be different for the -81 kg group at 71.6 ± 5.3 kg (702.16 ± 51.98 Nm) from arm extension at 78.2 ± 1.9 kg (766.88 ± 18.63 Nm). However, the difference was not clear when based on the effect size of the pairwise comparison (d = 1.914, 95% CI: -0.475 – 4.303). For the -90 kg weight category, there also was no difference between arm extension (81.3 ± 3.1 kg; 797.8 ± 30.40 Nm) and flexion (80.7 ± 5.2 kg, 791.4 ± 51.0 Nm): d = 0.176, 95% CI: -25.019 – 25.371, according to the authors, but the effect was not clear as well. Strength was assessed on a Dyno Concept 2000 [Morrisville, VT, USA].

Investigations on grip strength in martial arts and combat sports were mainly done in judo. For instance, Franchini, Takito, Kisset *et al.* [2005] found the right isometric hand grip strength of Brazilian elite male judoka to be 51 ± 10 kgf (254.97± 98.07 N) and 49 ± 10 kgf (480.53 ± 98.07 N) for the right and left hand, respectively. The values for the non-elite group were 42 ± 11 kgf (411.88 ± 107.87 N) and 40 ± 10 kgf (392.27 ± 98.07 N) for the right and left hand, respectively. Based on the p-value as reported by the authors, grip strength between hands was similar in both groups: p > 0.05. However, when considering the effect sizes, the difference between the right and left hands in the elite group was significant, albeit small (d = 0.202, 95% CI: -1.819 – 2.223) as well as in their non-elitecounterparts (d = 0.197, 95% CI: -1.883 – 2.276). The results were not clear for neither group.

Spanish university judoka were divided into weight categories and yielded the following values [Cortell-Tormo *et al.*, 2013]: for weight division 50 – 66 kg, grip strength was 44.85±6.63 kg (439.83±66.98 N) followed by 50.12±7.87kg (491.51±77.18 N) for the 67 – 81 kg and 54.15±7.16kg (531.03±70.22 N) for the +81 kg weight categories, respectively. Although not reported by the authors, the difference in absolute strength between the last two weight divisions was large: d = 0.548 (95% CI: -1.761 – 2.856) but inconclusive. The difference between the first two weight categories was large as well but equally unclear: d = 0.734(95% CI: -1.160 – 3.079).

Forthomme *et al.* [2002] investigated apparently healthy young (23 ± 3 years) women and men during hand pronation and supination at 90°/sec. Peak torque was normalized in ratio standard for the effect of body mass. Pronation strength of the dominant hand in the men was 10.5 ± 3.6 Nm/kg and 10.0 ± 3.8 Nm/kg for the non-dominant side. When expressed in terms of effect size, the difference was not significant: d = 0.139, 95% CI: -0.979 – 1.257, albeit not clear. Wrist torque in male students at 10°/sec and 20°/sec was reported to be 49.97Nm and 50.14 Nm, respectively. There also was a wrist position x direction x velocity interaction that was significant with $F_{77,1657}$ = 20.08 (95% CI: 20.0 ± 10.0) [Jung, Hallbeck 2002].

Basic aikido techniques consist from various wrist grips performed in so-called *gotai*, static regime. Defender performs movement against resistance of an attacker. That implies to use strength. In aikido, strengthening by specific methods in unusual. It is believed, that muscular development is comes along with learning and doing techniques. The type of grip used in different combat sports/martial arts vary according to the rules and the aim of the technique. In judo or jujutsu, the sleeve or collar grip is mainly used for which the strength of the thumb is important. In wrestling or MMA, various wrist, neck, ankle, or shoulder grips are employed. They put a strain on developing finger strength, especially when the opponent perspires. In aikido, as a non-competitive martial art, no maximal resistance of the training partner is expected. In addition, the main aim of the wrist grip, which is predominantly used, is to keep palm contact. Endo [2013] suggested that palm contact depended on the ability to move with the partner more than to hold him strongly. Many aikido techniques use extreme wrist flexion and extension [Eckert, Lee, 1993; Olson, Seitz and Guldbradsen, 1996]that may lead to injury if proper training, including strength conditioning [e.g. LaStayo *et al.* 2003], is not included in the program.

Compared to other combat sports/martial arts, research on aikido in general is scarce. For instance, aikido athletes were shown to have the third fastest choice reaction time [Şentuna *et al.* 2010], while [Seitz *et al.* 1990] focused on the effect of aikido on mental health. Şentuna *et al.* [2010] assessed simple auditory and visual reaction times as well as choice reaction time of the dominant and non-dominant hands of beginning and advanced (6 months – 2 years of experience) aikido practitioners. The authors concluded that simple visual reaction time (RT) of the dominant hand in the experienced group was significantly shorter, which was confirmed by the effect size for the pairwise comparison: 0.16 ± 0.02 sec vs. 0.22 ± 0.05 sec (d = 1.547 (95% CI: 1.537 – 1.556). No information is available on isokinetic strength of the upper extremities in aikido. The purpose of the current study, then, was to assess isokinetic strength of the wrist in recreational aikido athletes.

Methods

Male *aikido* practitioners (n=13, 33.23± 7.94 years, 180.62 ± 8.03cm, 80.31 ± 13.10 kg) were recruited from a summer camp organized at Masaryk University. All participants practiced aikido for more than one year regularly for two or three times per week. Average length of aikido practice was 8,50 ±5.01 years. Participants were more advanced than intermediate at the level of 3. Dan (n=1), 2. Dan (n=1), 1. Dan (n=5), 1. Kyu (n=5), and 3. Kyu (n=1). The project was approved by the university's review board (IRB) according to the Declaration of Helsinki.After signing the informed consent form, subjects were tested on a Cybex Humac Norm (Stoughton, MA, USA) at 120°, 180° and 240°/sec on both left and right wrists. They were requested and verbally encouraged to exert maximal effort. There was a 2-minute rest interval between angular velocities. Grip strength was assessed with a digital grip analyser (MIE medical research Ltd. Digital Analyser, Leeds, United Kingdom).

A 3-way Side (of the body) x Movement x Angular Velocity Manova with repeated measures on the second and third factors was used to assess the differences between right and left wrist extension and flexion by angular velocity. A 1-way Anova was employed to determine the difference in grip strength between the right and left hands. Comparisons were done in both absolute terms as well as relative to body mass in ratio standard and when allometrically scaled. The level of significance for all analyses was set to an effect size of 0.20.

Results

Table 1 displays the means and standard deviations of the strength variables by upper extremity. There was no statistically significant difference in absolute grip strength between the right (452.83 ± 96.84 N) and left (447.61 ± 89.18 N) hands (partial eta^2 = 0.001, 95% CI: -0.550 – 0.552; d = 0.058, 95% CI: -34.319–34.436) but the effects were not clear. There was also no difference between hands when grip strength was expressed in terms of body mass in ratio standard: 5.70 ± 1.24 N.kg^{-1} and 5.64 ± 1.15 N.kg^{-1} for the right and left hands, respectively (partial eta^2 = 0.0009, 95% CI: -0.530 – 0.572; d = 0.052, 95% CI: -0.389 – 0.494). Grip strength relative to allometrically scaled body mass did not differ between the right and left hands either: 76.76 ± 15.46 N.kg$^{-0.405}$and 75.91 ± 14.07 N.kg$^{-0.405}$, respec-

Table 1. Means (95% CI) and standard deviations (95% CI) of wrist extension and flexion by angular velocity in male aikidoka

	Right side	
Angular velocity	Extension	Flexion
120°/sec	16.85 (14.09 – 19.60) ± 4.56 (3.27 – 7.53)	25.46 (21.86 – 29.07) ± 5.97 (4.28 – 9.85)
180°/sec	15.85 (13.44 – 18.25) ± 3.98 (2.85 – 9.85)	23.77 (20.79 – 26.75) ± 4.94 (3.54 – 8.15)
240°/sec	15.15 (12.78 – 17.53) ± 3.93 (2.82 – 6.49)	17.23 (14.38 – 20.08) ± 4.71 (3.38 – 7.58)
	Left side	
120°/sec	15.39 (13.21 – 17.56) ± 3.60 (2.58 – 7.53)	22.85 (19.25 – 26.45) ± 5.96 (4.27 – 9.85)
180°/sec	13.77 (11.81 – 15.73) ± 3.24 (2.33 – 6.56)	21.08 (17.21 – 24.94) ± 6.40 (4.59 – 8.15)
240°/sec	17.23 (14.38 – 20.08) ± 4.71 (3.38 – 6.49)	17.23 (14.38 – 20.08) ± 4.71 (3.38 – 6.49)

Table 2. Simple effects analysis of the Movement x Angular Velocity interaction (d ± 95% CI)

	Extension 120°/s 13.89 ± 3.50	Flexion 120°/s 22.42 ± 5.71	Extension 180°/s 18.85 ± 4.65	Flexion 180°/s 16.12 ± 4.11	Extension 240°/s 14.81 ± 3.63	Flexion 240°/s 24.15 ± 5.96
Extension 120°/s 13.89±3.50						
Flexion 120°/s 22.42±5.71	1.875 (0.126–3.624)					
Extension 180°/s 18.85±4.65	1.254 (-0.265–2.774)	0.714 (-1.209–2.637)				
Flexion 180°/s 16.12±4.11	0.608 (-0.802–2.018)	1.318 (-0.519–3.155)	0.648 (-0.973–2.268)			
Extension 240°/s 14.81±3.63	0.269 (-1.048–1.585)	1.656 (-0.111–3.422)	1.008 (-0.532–2.549)	0.352 (-1.080–1.784)		
Flexion 240°/s 24.15±5.96	2.185 (0.380–3.990)	0.309 (-1.847–2.464)	1.032 (-942–3.006)	1.633 (-0.258–3.523)	1.970 (0.148–3.792)	

tively (partial eta^2 = 0.0009, 95% CI: -0.530 – 0.572; d = 0.060, 95% CI: -5.399 – 5.519).

There was no Side x Movement x Angular velocity interaction for isokinetic wrist strength (partial eta^2 = 0.011, 95% CI: -0.473– 0.620) but the effect was not clear. There was a Movement x Angular velocity interaction (partial eta^2 = 0.859, 95% CI: 0.451–0.954). Table 2 depicts the results of the simple effects analysis.

There was no Side x Velocity interaction for isokinetic wrist strength (partial eta^2 = 0.028, 95% CI: -0.422 – 0.658) and also no Side x Movement interaction (partial eta^2 = 0.046, 95% CI: -0.382 – 0.684) but neither of the effects was clear. There was no main effect for Side (partial eta^2 = 0.080, 95% CI: -0.317 – 0.722), which was not clear as well. However, there were distinct main effects for Movement (partial eta^2 = 0.905, 95% CI: 0.840 – 0.986) and Angular Velocity (eta^2 = 0.636, 95% CI: 0.441 – 0.937).

Discussion

Table 3 displays comparative values for grip strength in martial arts and combat sports. Taiwanese sedentary men of the same age group (30 – 34 years) as the *aikidoka*, with a mean age of 38.1 years (Wu *et al.*, 2009), recorded a combined right and left grip strength of 38.1 kg (95% CI: 33.2 – 43.0 kg) or 373.63 N (95% CI: 325.58 – 421.69 N). Collapsed over side of the body, the *aikidoka* had a grip strength of 450.22 ± 91.24 N; 95% CI of the mean: 413.36 – 487.07 N, which is statistically not different from that of the Taiwanese. Right hand grip strength of an older group (65 – 69 years) of Taiwanese men [Liao *et al.*, 2014] was 34.3 ± 5.1 kg (336.37 ± 50.01 N), which is significantly different from that of the *aikidoka*'s but the effect is not clear (d = 1.633 (95% CI: -23.884 – 27.151). Compared to normative data for American age group counterparts from the general population in the age range of 30 – 34 years [Mathiowetz *et al.* 1985], who recorded a grip strength of 121.8 ± SE 4.4 lbs (541.79 ± SD 22.34 N), the *aikidoka* scored lower on the right hand but the effect was not clear: d = 3.096, 95% CI: -0.038 – 6.230. The value for the left hand of the Americans was 110.4 ± SE 4.2 lbs (491.08 ± SD 18.68 N), which was also higher than that of the *aikidoka*, although equally unclear (d = 1.733, 95% CI: -1.003 – 4.469). It is possible that the difference may be due to the equipment used. The Americans were tested with a Jamar hydraulic hand dynamometer [Lafayette Instrument, Lafayette, IN, USA].

Franchini *et al.* [2011] compared isometric hand grip strength of elite judoka and reported values of 51 ± 10 kgf (500.14 ± 98.07 N) and 49 ± 10 kgf (480.53 ± 98.07 N) for the right and left hands, respectively. Their non-elite counterparts recorded 42 ± 11 kgf (411.88 ± 107.87 N) and 40 ± 10 kgf (392.27 ± 98.07 N) for the right and left hands, respectively. Although not indicated by the authors, the difference between the elite and non-elite group on the right side was significant, albeit inconclusive (d = 0.202, 95% CI: -19.618 – 20.023). For the left side, the difference was large but also not clear when taking

Table 3. Comparative descriptive statistics for grip strength [kgf (N)] by side of the body in martial arts and combat sports

Combat sport (Study)	Right	Left
Aikido (this study)	452.83 ± 96.84	447.61 ± 89.18
Judo (Little, 1991)	57.7 ± 9.0 (565.84±88.26)	54.0±10.4 (529.56±101.99)
Wrestling (14 – 17 years) (Roemmich and Frappier, 1993)	Successful: 53.2±2.4kg (SE*) [521.71±23.54 N (SE); 10.46 (SD*)] Less successful: 47.2±SE 1.8 kg [462.87±17.65 N (SE); 76.94 (SD)] *SE: standard error *SD: standard deviation	Successful: 52.8±2.2 kg (SE*) [517.79±21.58 N (SE); 94.07 (SD*)] Less successful: 47.2±SE 1.8 kg [462.87 17.65 N (SE); 76.94 (SD)] *SE: standard error *SD: standard deviation
Judo (university team, 2000) (Franchini *et al.*, 2005)	54.3±8.3 (532.50±81.40)	53.27.4 (521.71±72.57)
MMA (Schick *et al.*, 2010)	45.8±6.2 (449.15±60.80)	45.6±5.9 (447.18±57.86)
Boxing (Schick *et al.*, 2010)	58.2±6.9 (570.75±67.67)	--
Judo (university team, 1996) (Franchini *et al.*, 2011)	49.5±12.8 (485.43±125.53)	47.2±12.4 (462.87±121.60)
Junior elite wrestlers (Demirkan *et al.*, 2012)	49±8 (480.53±78.45)	48±7.9 (470.72±77.47)
Brazilian jiujitsu (Vidal Andreato *et al.*, 2011)	43.7±4.8 (428.55±47.07)	40.1±3.8 (393.25±37.27)
Judo (Claessens *et al.*, 1984)	59.7 ± 8.8 (585.46 ±86.30)	64.9 ± 8.9 (636.45 ±87.28)
Judo (Farmosi, 1980)	59.9 ± 11.2 (487.42 ± 109.84)	55.7 ± 10.7 (546.23 ± 104.93)

into account the effect size of the pairwise comparison: d = 0.910 (95% CI: -18.911 – 20.731).

Hand grip strength in judo was assessed by Detanico *et al.* [2012] using the judo uniform pull test. There was a significant difference between the dominant (478.85 ± 175.13 N) and non-dominant hands (418.54 ± 126.46 N) based on the point estimates of the p-value (0.0114) with a model effect size of 0.59 (95% CI: 0.47 – 0.91). The authors reported the correlation between body mass and absolute pull test (N) to be r = 0.51 with a p-value of 0.00294. The accuracy (95% CI) of the relationship was: 0.057 – 0.789 with a shared variance of 26.01% (95% CI: 5.74 – 46.28), which is not as clear as the point estimate suggests and warrants caution when drawing conclusions.

Sedentary male university students had a right grip strength of 49.3 ± 11.2 kg (219.30 ± 49.82 N) [Marley, Thomson 2000]. The authors did not find any interactions for isokinetic wrist strength involving movement and angular velocity. Their subjects were assessed at 60°, 120° and 180°/sec. However, they did find main effects for movement (F_1 = 153.61, 95% CI: 119 – 184) and angular velocity (F_2 = 27.47, 95% CI: 16 – 39). Collapsed over angular velocity, wrist flexion (12.38 ± 5.05 Nm) was higher than wrist extension (7.31 ± 4.15 Nm): d = 1.121, 95% CI: -0.159 – 2.401) but the effect was not clear. The main effect for angular velocity indicated that peak torque at 60°/sec (11.46 ± 3.77 Nm) was higher than at 120°/sec (9.77 ± 3.78 Nm, d = 0.457, 95% CI: -0.588 – 1.503) and 180°/sec (8.42 ± 3.34 Nm, d = 0.872, 95% CI: -0.114 – 1.858), but the effects were not clear. There was a large difference between peak torque at 120°/sec (9.77 ± 3.78 Nm) and at 180°/sec (8.42 ± 3.34 Nm, d = 3.94, 95% CI: -0.923 – 1.711) but the effect for the pairwise comparison was also not definitive.

A significant main effect for direction (wrist extension/flexion) was reported by Morse *et al.* [2006] in sedentary men and women: $F_{1,18}$ = 19.4 (95% CI: 19.3 – 19.5). Collapsed over gender and angular velocity, isokinetic strength during wrist flexion (8:21 ± 4.83Nm) was larger than wrist extension (5.61 ± 2.54 Nm, d = 0.691, 95% CI: -0.474–1.857), but the difference was not clear-cut. The participants were assessed at angular velocities of 15°, 30°, 45°, 60°, 75°, and 90°/s. In other words, the disparity in peak torque during wrist extension and flexion persisted regardless of level of physical activity.

Allometric scaling in the aikidoka tested did not control for the effect of body mass on wrist strength over and above the ratio standard approach. Previous research showed that differences decreased when strength (1 RM bench press in kg)was expressed in terms of lean body mass using the theoretical exponent: 6.33 ± 2.20 kg.kg$^{-0.67}$for the men vs. 3.79 ± 0.61 kg.kg$^{-0.67}$ for the women (partial eta^2 = 0.60, 95% CI: 0.50 – 0.91) [Pieter, Bercades 2010]. However, this was not the case in the current study. It is suggested that the differences may be related to how large the body part is that is involved in the strength measure. That is, the larger the body part, the more (allometric) scaling may control for its effect.

Future research should also include the positions at peak torque. Marley and Thomson [2000] reported wrist position of peak torque at 180°/sec to occur later than at 60°/sec. Similar observations were also relayed by Pieter and Taaffe [1990] in taekwondo for isokinetic leg strength. American elite male and female taekwondo athletes reached peak torque earlier during leg extension at the knee joint than leg flexion with increasing angular velocity. It is suggested that this is related to the so-called catch-up phenomenon, i.e., weaker muscle groups are thought to take longer to catch up with the velocity of the isokinetic machine [Osternig 1986].

Conclusion

Aikidoka have weaker handgrip strength than other combat sports/martial arts athletes. The purpose of grip and the way how it is performed while throwing or pining a partner differs from using grip in other martial arts. Based on the current results, strength exercises for wrist extension in aikido athletes may be indicated, especially when using weapons, where extension is more important in hand techniques. In the future, in vivo experiment should be examined after programming hand and forearm strength program.

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Izokinetyczna siła nadgarstka u zawodników aikido

Słowa kluczowe: sztuki walki, siła rąk, moment obrotowy, biomechanika

Abstrakt

Tło. Nie istnieje zbyt wiele badań fizjologicznych dotyczących *aikido*. Chociaż w technikach stosowanych w tej sztuce walki należy zachować szczególną ostrożność przy zginaniu i prostowaniu nadgarstka, który często ulega uszkodzeniu, nie ma wielu dostępnych informacji na temat izokinetycznej siły kończyn górnych w aikido. Badania, w których obserwowano siłę chwytu w sztukach walki i sportów walki dotyczyły głównie *judo*.

Cel. Celem obecnych badań była ocena izokinetycznej wytrzymałości nadgarstka osób trenujących aikido rekreacyjnie.

Materiał i metody. Mężczyźni ćwiczący aikido (n = 13, 33,23 ± 7,94 lat, 180.62 ± 8,03 cm, 80.31 ± 13.10 kg) byli uczestnikami letniego obozu zorganizowanego na Uniwersytecie Masaryka. Uczestnicy badania byli testowani wg *Cybex Humac Norma* 120°, 180° and 240°/s, na lewym i prawym nadgarstku. 3-kierunkowy test ANOVA (strona x ruch x prędkość kątowa) z powtarzanymi pomiarami przy drugim i trzecim czynniku w celu oceny różnic między wyprostem i zgięciem prawego oraz lewego nadgarstka przy danej prędkości kątowej. Poziom istotności dla wszystkich analiz został ustawiony na wielkość efektu 0,20.

Wyniki. Zaistniała interakcja Ruch x Prędkość kątowa (eta^2 = 0.859, 95% CI: 0.451– 0.954). Prosta analiza rezultatów wykazała, że wartość wyprostu nadgarstków w ciągu 240°/sec (13.27 ± 3.18 Nm) była niższa niż wartość zgięcia nadgarstków (23,55 ± 6,66 Nm), przy tej samej prędkości kątowej (d = 2,050, 95% CI: 0,123 – 3,978), chociaż rezultat nie był jasny. Wartość zgięcia dla 120°/sec (31,64 ± 8,06 Nm) była wyższa niż dla 180°/s (28.50 ± 7.10 Nm), ale rezultat również nie był jasny: d = 0,430 (95% CI: -2,375 – 3,235).

Wnioski. Na podstawie obecnych wyników, można stworzyć ćwiczenia wytrzymałościowe na wyprost nadgarstka dla sportowców trenujących aikido, choć będzie potrzebne są dalsze badania w celu ustalenia ostatecznej konkluzji. Badania te powinny obejmować osoby w różnym wieku i z różnym doświadczeniem, nie tylko mężczyzn, ale i kobiety. Przyszłe analizy powinny brać pod uwagę szczytowy momentu obrotu. Adepci aikido mają słabszą siłę uchwytu niż zawodnicy w innych sportach lub sztukach walki. Na podstawie obecnych wyników, ćwiczenia wytrzymałościowe na wyprost nadgarstka u sportowców aikido mogą być wskazane zwłaszcza, gdy używana jest broń, i szczególnie w walce wręcz, gdy wyprost nadgarstka jest bardzo ważny.