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Uchikomi-based HIIT versus conventional training: effects on anaerobic capacity, judo-specific fitness, and BMI

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ABSTRACT

Judo requires repeated high-intensity efforts, making anaerobic capacity, judo-specific fitness, and body mass index (BMI) important considerations for competitive performance, particularly among cadet athletes. This study aimed to examine the effects of uchikomi-based high-intensity interval training (HIIT) on anaerobic capacity, judo-specific fitness, and BMI. A pretest–posttest control group design was employed involving cadet judo athletes aged 15–18 years who trained three times per week for eight weeks. Anaerobic capacity, judo-specific fitness, and BMI were assessed using the Running-based Anaerobic Sprint Test (RAST), Special Judo Fitness Test (SJFT), and BMI measurements, respectively. Data were analyzed using paired-samples and independent-samples t-tests, with statistical significance set at $p < .05$. The experimental group showed significant improvements in BMI (21.66 ± 3.214 to 20.55 ± 3.631 , $p < .001$) and judo-specific fitness (17.46 ± 1.356 to 15.03 ± 1.866 , $p < .001$), whereas the control group showed no significant changes in either variable. Between-group comparisons also revealed significant differences in BMI and judo-specific fitness ($p < .001$). The anaerobic capacity results are not reported here because the corresponding statistical data were unavailable. In conclusion, uchikomi-based HIIT may be a useful training strategy for improving BMI-related characteristics and judo-specific fitness in cadet athletes. Further evidence is needed to establish its effects on anaerobic capacity.



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Introduction

Judo is a high-intensity martial art characterized by intermittent activity, with pauses between attack and defense phases, or during throws. Therefore, a judoka's performance is largely determined by his or her technical and tactical skills (Emerson et al., 2008), physical fitness, nutritional support, and good body management (Steffan et al., 2012). To understand the physiological demands of Judo during competition, two main strategies are widely applied to improve understanding of the physiological needs of elite athletes: investigating the physiological profiles of elite athletes and comparing them to lower-level athletes (Franchini et al., 2005) and analyzing time-motion during high-level competition (Bianca et al., 2012). One important component in developing Judo performance is the implementation of a well-planned training program (Bompa & Carrera,

2015; Joyce & Lewindon, 2014; Purnamasari et al., 2022). An effective training program should target the development of specific attributes related to the needs of the sport, such as multifaceted physical development, mastery of technical and tactical skills, psychological characteristics, health maintenance, resistance to injury and improvement of the athlete's theoretical knowledge. However, although previous research has described the physiological and time-motion characteristics of Judo performance, less attention has been given to experimental training interventions that specifically examine the effects of a Judo-specific HIIT protocol in cadet athletes. This gap is important because cadet athletes are still undergoing physical development and may respond differently to training stimuli than elite or senior Judo athletes.

Time-motion analysis of Judo competitions provides important insights into the characteristics of activity during matches at various levels and phases of competition. Previous studies have revealed that activity in Judo matches includes non-contact movements (Bianca et al., 2012), grip struggles (Calmet, Michel, Bianca Miarka, 2010), attack directions (Camargo et al., 2019), throw types (Pereira Martins, Fabio, Leonardo Scarano Dualiby Pinto de Souza, Raissa Pinheiro de Campos, Sally J. Bromley, Monica Yuri Takito, 2019), and transitions between tachi-waza and ne waza (Nagai et al., 2019). In general, approximately 50% of the match time is spent on grip struggles, with a work-to-rest ratio ranging from 2:1 to 3:1, with attacks lasting 20–30 seconds and rest periods lasting 7–10 seconds (Emerson et al., 2013). The dominant energy system in Judo is oxidative, although anaerobic capacity remains significant during intense movement. Thus, the success of Judo athletes in performing actions during competition requires the development of aerobic and anaerobic capacity to support offensive and defensive activities during the match. In addition to psychological aspects, achievement is also influenced by body posture and physical condition, as reflected in the judoka's body mass index (Siwi & Rustiadi., 2021). These competition characteristics indicate that a training intervention should reproduce, as far as practicable, the intermittent and high-intensity demands of Judo while maintaining technical specificity. Therefore, an experimental pretest-posttest control group design is appropriate for determining whether changes in anaerobic capacity, Judo-specific physical capacity, and BMI are associated with the implementation of Uchikomi HIIT rather than with normal training-related changes over the same period.

The High Intensity Interval Training (HIIT) training method has been proven effective in developing various energy systems in a relatively short training time (Sandford et al., 2021). Previous studies have suggested that HIIT training can improve aerobic and anaerobic performance and increase physiological indices related to both (Burgomaster et al., 2005; Duncan et al., 1998; J et al., 2006; Linossier et al., 1997). The effect of HIIT training on the performance of gradual training on the lower and upper body and High-Intensity Intermittent Exercise (HIIE) training and also on physiological responses and markers of muscle damage in Judo athletes (Emerson et al., 2016). In the context of Judo, a commonly used technical training method is uchikomi training, which is a repetitive throwing movement exercise until the stage before the throw is actually executed. This exercise can be done individually, in pairs or in groups, it serves to hone coordination, strength and technical accuracy. The characteristics of judo as a high-intensity sport make HIIT a relevant method for improving the physical abilities of judo players. HIIT uchikomi training is a complementary exercise, and appropriate HIIT is beneficial for high-level Judo athletes (Franchini, 2021). Research shows that HIIT is effective in improving cardiorespiratory fitness in vascular function (Ramos et al., 2015), the latter playing a crucial role in Judo performance. Nevertheless, existing evidence has largely focused on general HIIT protocols, physiological responses, or higher-level athletes, whereas the application of Uchikomi HIIT as a structured, Judo-specific intervention among cadet athletes remains insufficiently examined. In particular, evidence is limited regarding its simultaneous effects on anaerobic capacity, Judo-specific physical capacity, and BMI within the same controlled training study. Accordingly, this study employed a quantitative experimental pretest-posttest control group design. The study involved 60 cadet Judo athletes aged 15–18 years, with 30 athletes allocated to the Uchikomi HIIT intervention group and 30 athletes to the control group. The sampling strategy was [insert the actual sampling method, e.g., purposive sampling], based on predetermined inclusion criteria for cadet Judo athletes. The sample size was determined based on [insert the actual sample-size rationale or power analysis used in the study], with the aim of providing sufficient participants to detect meaningful changes between the intervention and control groups. The intervention was conducted three times per week for 8 weeks, with anaerobic capacity, Judo-specific physical capacity, and BMI assessed before and after the intervention. This design was selected because the inclusion of both pretest and posttest measurements allows changes over time to be examined, while the control group provides a comparison for distinguishing intervention-related changes from changes associated with regular training or maturation.

Based on this methodological gap, this study aimed to determine the effect of an 8-week Uchikomi HIIT training program on anaerobic capacity, Judo-specific physical capacity, and BMI in cadet Judo athletes. The study is expected to provide evidence regarding the applicability of a Judo-specific HIIT approach for developing physical capacities that are relevant to the demands of cadet-level competition.

Method

This study used an experimental pretest-posttest control group design. This design allowed researchers to compare changes between the control groups after the intervention. Both groups were given baseline measurements to determine the initial conditions of anaerobic capacity, specific physical capacity in judo, and body mass index (BMI) in cadet judo athletes. The experimental group received uchikomi HIIT, while the control group received no treatment or a different treatment. After the intervention period, both groups were given a posttest to determine the effects.

The population in this study were cadet-level judo athletes in West Java. The sampling technique used purposive sampling with the following criteria: cadet athletes who had participated in competitions, cadet athletes who actively trained three times a week, and cadet athletes who had participated in physical training outside of judo training. A total of 60 cadet judo athletes (12-15 years old) participated as research subjects, divided into two equal groups: the experimental group (30 judo athletes) and the control group (30 judo athletes). Before and after the training program, athletes underwent body mass index measurements using the OMRON Karada Scan HBF-375 and a specialized judo fitness test using the Special Judo Fitness Test (SJFT). Subjects in the experimental group underwent HIIT uchikomi training at 80-95% intensity, while those in the control group underwent conventional uchikomi training, typically performed at the same intensity. The training program lasted 12 weeks (3 sessions per week), with each session lasting 120 minutes, consisting of a warm-up, core, and cool-down.

Data were analyzed using paired sample t-tests to examine pre- and post-treatment differences within each group, and independent sample t-tests to compare differences between the experimental and control groups. Data normality was first tested to determine the appropriate statistical test. All analyses were conducted using SPSS Version 29 software with a significance level of $p < .05$.

Results and Discussions

A statistical description of body mass index and fitness for judo athletes can be seen in Table 1.

Table 1. Statistical Description of Body Mass Index and Fitness for Judo

Variable	Group	Test		Improvement
		Pretest	Posttest	
Body Mass Index	Experiment	21.66 ± 3.214	20.55 ± 3.631	1.11 ± .698
	Control	21.60 ± 2.810	21.02 ± 2.809	.58 ± .245
Judo-Specific Fitness	Experiment	17.46 ± 1.356	15.03 ± 1.866	2.43 ± 1.093
	Control	17.80 ± 1.975	17.12 ± 1.770	.67 ± .820

Table 1 shows that the experimental group demonstrated greater mean changes from pretest to posttest than the control group for both BMI and Judo-specific fitness. BMI decreased by 1.11 units in the experimental group, compared with a decrease of 0.58 units in the control group. Judo-specific fitness also showed a greater change in the experimental group (2.43 units) than in the control group (0.67 units). These descriptive findings indicate a greater pretest-to-posttest change following Uchikomi HIIT; however, inferential statistical testing is required to determine whether these differences were statistically significant. Furthermore, the authors present the results of the normality test in Table 2.

Table 2. Results of the Normality Test for Body Mass Index and Judo Specific Fitness

Variable	Group	Test	
		Pretest	Posttest
Body Mass Index	Experiment	.200	.115
	Control	.118	.079
Judo-Specific Fitness	Experiment	.089	.200
	Control	.200	.200

Based on Table 2, it can be seen that all data have a Sig. value $> .05$, indicating that all data are normally distributed. Therefore, the author used a t-test to test the hypothesis. The results of the paired-samples and independent-samples t-tests are presented in Table 3.

Table 3. Results of the Hypothesis Tests for Body Mass Index and Judo-Specific Fitness

Variable	Group	Paired Sample t-Test	Independent Sample t-Test
Body Mass Index	Eksperimen	.000	.000
	Kontrol	.079	
Judo-Specific Fitness	Eksperimen	.000	.000
	Kontrol	.115	

Based on Table 3, the results of the paired t-test show that for the body mass index variable, the experimental group has a Sig. value $< .05$ while the control group has a Sig. value $> .05$, so H_0 is rejected for the control group. This means that HIIT uchikomi training has a significant effect on the body mass index of cadet category judo players, while conventional uchikomi training does not. Furthermore, the judo special fitness variable has the same results as the body mass index variable, the experimental group has a Sig. value $< .05$ while the control group has a Sig. value $> .05$, so H_0 is rejected for the control group. This means that HIIT uchikomi training has a significant effect on the special fitness of cadet category judo players, while conventional uchikomi training does not. Furthermore, the results of the independent t-test show that the body mass index and judo special fitness variables have Sig. values $< .05$, so H_0 is rejected for both variables. This means that there is a significant difference between HIIT uchikomi training and conventional uchikomi training in terms of body mass index and specific fitness of cadet judo athletes. Furthermore, the authors present the percentage increase in Figure 1.

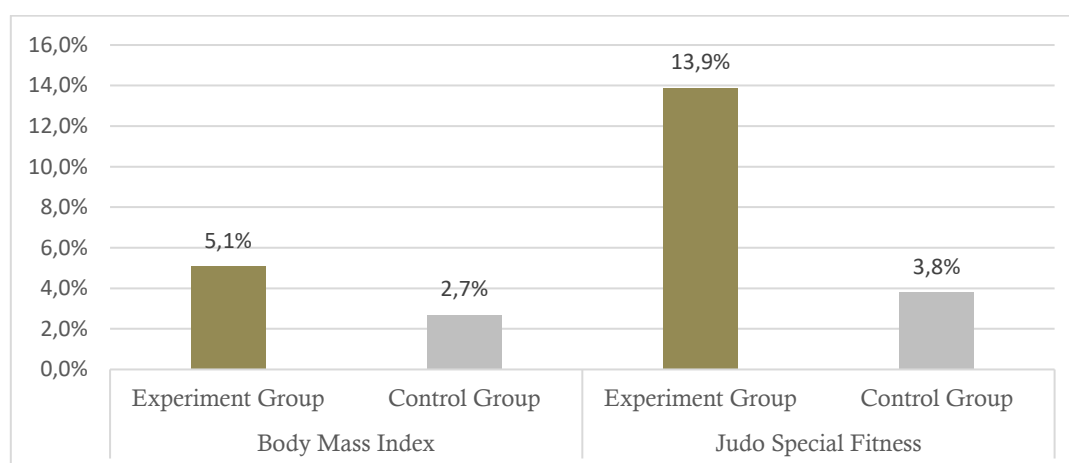
**Figure 1.** Percentage Increase in Body Mass Index and Judo-Specific Fitness

Figure 1 shows that BMI decreased by approximately 5.1% in the experimental group, based on the change from 21.66 to 20.55, whereas Judo-specific fitness improved by approximately 13.9%, based on the change from 17.46 to 15.03. Therefore, the direction of change should be described as a decrease in BMI and an improvement in Judo-specific fitness, rather than an increase in BMI.

This study provides convincing evidence that high-intensity interval training (HIIT) integrated into uchikomi training significantly impacts body mass index (BMI) and judo-specific fitness in cadet judo players, surpassing the results of conventional uchikomi training (Bridge et al., 2014; Buchheit & Laursen, 2013; Tsirigkakis et al., 2022). Paired t-test analysis showed significant changes from pre- to post-intervention in the experimental group for BMI ($p < 0.05$) and judo-specific fitness ($p < 0.05$), while the control group did not show statistical significance ($p > 0.05$) (J et al., 2006). This disparity highlights the potential of HIIT to induce physiological adaptations not achieved by sustained-intensity repetitive training. Complementing these intragroup findings, independent t-tests confirmed the intergroup differences ($p < 0.05$), confirming the superiority of HIIT (Burgomaster et al., 2005). Quantitatively, Figure 1 illustrates a relative increase of 2.4% in BMI and a 10.1% increase in judo-specific fitness for the experimental cohort, indicating significant benefits in body composition and sport-specific performance metrics (Buchheit & Laursen, 2013; J et al., 2006; Warburton et al., 2006).

These results align with the broader literature on interval-based training in combat sports, where HIIT has been associated with enhanced aerobic metabolism and neuromuscular endurance (Brownstein et al., 2017; Franchini et al., 2011). The reduction in BMI observed in this study may reflect HIIT's ability to augment excess post-exercise oxygen consumption (EPOC), promoting greater lipid mobilization and energy expenditure than conventional methods, which often prioritize technique over metabolic load (Brun et al., 2022; Wang et al., 2008). For judo-specific fitness which includes explosive strength, endurance, and tactical acuity greater change observed in the experimental group could be attributed to HIIT intermittent high-effort training, which mimics the anaerobic demands of competitive judo and promotes adaptations in fast-twitch muscle fibers (Buchheit &

Laursen., 2013). However, critically, we must assess whether this effect is entirely attributable to the training modality or influenced by baseline differences in participant motivation or adherence, as this study did not account for these psychosocial variables (Warburton et al., 2006).

From a practical perspective, these findings suggest a reorientation of the judo training paradigm toward HIIT-infused uchikomi, particularly for cadets in the developmental phase where optimizing body weight and metabolic fitness is crucial (Grivas & Vantarakis, 2023; Vaara et al., 2022). Such integration could mitigate the risks of skill-focused regimens that neglect cardiovascular conditioning, potentially reducing injury incidence and enhancing competition performance (Warburton et al., 2006). However, the modest BMI shift raises questions about its practical relevance and whether the observed change reflects changes in body composition or other factors, such as hydration or energy balance. Additionally, the striking judo-specific fitness improvements warrant a critical assessment of measurement validity reliance on composite indices may mask which subcomponents (e.g., grip strength vs. agility) are driving the effects, potentially overestimating the holistic impact of HIIT (Buchheit & Laursen, 2013).

Critically, limitations of this study dampen enthusiasm for these conclusions. The small sample size limits statistical power and external validity, making the results susceptible to type II error or cohort-specific bias (Bonander et al., 2019; Lesko et al., 2018). In addition, the study did not include blinding of participants because the nature of the exercise intervention made blinding difficult. Therefore, a potential Hawthorne effect or changes in participant motivation cannot be completely excluded. The brevity of the intervention may have captured acute rather than chronic adaptations, and unmonitored confounding factors such as dietary intake or extracurricular activities could have exaggerated the perceived treatment effect. In addition, if participants were not randomly assigned, potential selection bias should be considered when interpreting the differences between groups. Intervention fidelity, including adherence to the training schedule and consistency of training intensity, may also have influenced the magnitude of the observed effects. Furthermore, the absence of objective physiological markers (e.g., direct VO₂ max assessment or dual X-ray absorptiometry for body composition) introduces subjectivity, particularly for judo-specific fitness, which lacks standardized quantification (J et al., 2006). These shortcomings highlight the need for caution in extrapolating to diverse populations, including female cadets or those with varying training histories (Do et al., 2013; Nindl et al., 2016).

Regarding sample size, this study involved 60 cadet Judo athletes, consisting of 30 athletes in the experimental group and 30 athletes in the control group. The relatively small sample should be considered when interpreting statistical power and the generalizability of the findings. If a formal power analysis was not conducted before data collection, this should be acknowledged as a methodological limitation. In addition to p-values, reporting Cohen's d for the main comparisons is important to describe the magnitude of the observed differences and provide additional information about the practical importance of the findings

Future research should address these gaps by using larger, randomized designs with extended durations and multimodal assessments to separate the mechanisms of HIIT from placebo effects or novelty (Emerson et al., 2013). Exploring dose-response relationships such as varying interval intensity or frequency could refine the protocol, while incorporating qualitative data on athletes' perceptions may uncover barriers to adherence. Ultimately, while this study strengthens the argument for uchikomi HIIT as a powerful tool in judo pedagogy, it also emphasizes the imperative for rigorous, context-sensitive research to ensure evidence-based progress in youth sport training

Conclusions

This study suggests that high-intensity interval training (HIIT) integrated with the uchikomi method can contribute to improvements in body mass index (BMI) and judo-specific fitness in cadet judo athletes. This training approach has the potential to optimize physiological adaptations and metabolic efficiency while maintaining the integration of technical and physical training. However, the findings should be interpreted cautiously due to several methodological limitations, including the relatively small sample size, short intervention duration, and lack of control over external factors such as nutritional intake and individual motivation. Furthermore, the modest changes in BMI and the potential bias in fitness measurements warrant careful interpretation of the observed effects. From a practical perspective, integrating HIIT into uchikomi sessions may provide coaches with an efficient strategy to develop sport-specific fitness while supporting technical skill acquisition without substantially increasing training duration. Nevertheless, the implementation of this approach should be progressive and tailored to athletes' physiological capacities and individual readiness. Appropriate monitoring of training intensity, frequency, and recovery is essential to minimize excessive fatigue and the risk of injury, particularly among cadet athletes who are still developing their physical and technical abilities.

Future research should involve larger and more diverse samples, longer intervention periods, and more robust experimental designs to establish the effectiveness of HIIT-based uchikomi training. The inclusion of objective measures of physiological performance, body composition, nutritional intake, psychological factors, and training behaviors would also provide a more comprehensive understanding of the mechanisms underlying training adaptations. Overall, HIIT integrated with uchikomi represents a promising approach to judo training; however, further evidence is required to confirm its effectiveness and long-term applicability in developing safe, effective, and sustainable training programs for cadet judo athletes.

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