Physiological characteristics of aikido practitioners and aikido workouts

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A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: Aikido is a philosophy and a Japanese art of self-defense, practiced nowadays all over the word as a lifelong recreational activity. Although it is claimed to have beneficial effects on physical health, empirical evidence is scarce. Our study aims is knowledge about the cardiovascular load of traditional aikido workouts, and various aspects of aikido practitioners' fitness.

Material and Methods: Thirty-eight (age: 36.3 ±9.28 years) male Hungarian aikido practitioners were measured with respect to maximum oxygen uptake (VO2max), body composition, strength, and flexibility. Cardiovascular load posed by aikido workouts were also assessed with continuous heart rate measurement.

Results: The percentage of time spent in the aerobic and anaerobic heart rate training zones was 35.2 ±17.34% and 16.5 ±18.43%, respectively. Average values were better in the aikido group than the gender and age matched reference values for maximal oxygen uptake (t_{37} = 3.352; p = 0.002, ES = 0.544), body mass index (Wilcoxon statistic = 220.0; p = 0.030, ES = −0.406), body fat (t_{37} = −1.804; p = 0.079, ES = −0.293), and lateral side bending (t_{37} = 4.433; p<0.001, ES = 0.719). However, the aikido group was inferior with respect to sit-and-reach values (t_{37} = −6.175; p<0.001, ES = −1.002), body muscle percent (Wilcoxon statistic = 77.00; p<0.001, ES = −0.792), and hand grip strength (t_{37} = −3.648; p<0.001, ES = −0.592). No difference between the grip strength of the two hands was found (t-test: t_{37} = 0.726; p = 0.473, ES = 0.118).

Conclusions: Considering the recommendations of the American College of Sports Medicine, aikido represents a recreational activity with considerable health protective effects. To optimize its beneficial effects, however, additional emphasis on resistance training, muscle strength, and the avoidance of injuries are needed.

Keywords: body composition • budo • maximal oxygen uptake • resistance training • training load • training zone

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Budo (Budō) – originally a term denoting the "Way of the warrior", it is now used as a collective appellation for modern martial arts of kendō, jūdō, kyūdo and so on. The primary objective of these "martial ways" is self-perfection (ningen-keisei) [28].

Dan (dan'i) – a term used to denote one's technical level or grade. In ***jūdō***, the "***dan***" ranks start at shodan (1- ***dan***) and go up to the highest grade of ***jūdan*** (10- ***dan***) [29].

Kyū – the series of grades that precede ***dan*** ranks. ***Ikkyū*** is the grade immediately below ***shodan*** [29].

Periodisation – ***noun*** the act of planning a long-term training schedule for professional athletes, working around competitions [30].

Resistance training – ***noun*** training that increases muscle strength by working against resistance such as a weighted dumbbell or barbell [30].

Technique– ***noun*** a way of performing an action [30].

Workout – ***noun*** a session of strenuous physical exercise or of practising physical skills as a way of keeping fit or as practice for a sport [30].

Training load – "A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' interchangeably with 'volume of physical activity'. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (...) As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '***workload volume***'. (...) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of ***training load*** defined as the amount of workload. It is useful in analyses with a high level of generality. (...) In current research and training

INTRODUCTION

Aikido is a Japanese martial art (budo) invented in the early twentieth century, and practiced nowadays in 130 countries around the world [1]. Its founder, Morihei Ueshiba, developed it after extensively studying several armed and unarmed systems of combat. Aikido is a fighting art, a method of self-defense, and at the same time a philosophy, with the aim to *"improve one's character according to the rules of nature" [*1]. The name can be interpreted as „the way of spiritual harmony", where „ai" means harmony, connection, „ki" refers to spirit, life or cosmic energy, and „do" is a method, a way. Aikido is typically practiced in pairs; the defender (*tori*) intends to defend him or herself without causing harm to the attacker, and create a harmony of movements. This is achieved by blending with the motion of the attacker and redirecting the force of the attack, based on moving from the center of the body in a calm and aware state, by circular and spherical movements [1, 2, 3]. Throws, rolls, twists, and force downs (with pins and joint locks) belong to the characteristic techniques of aikido. Based on the philosophy of aikido and the statements of practitioners, many beneficial physiological and psychological health effects could be attributed to aikido.

Rogers [4] described recreational exercise as a participation in any physical activity during leisure time that does not involve formal competition or monetary payment. The humanistic approach to exercise emphasizes freedom of choice when exercising, the joy of effort, and aids in establishing lifetime participation. Recreational exercise is intrinsically motivated, characterized by positive affect and joy, and substantially contributes to the individual's stress management. Exercise activities that have the following features are good choices for enhancing the psychological benefits of exercise. They should: influence participants breathing patterns; include relatively little interpersonal competition; closed; predictable or temporally and spatially certain; and exhibit rhythmical and repetitive movements. As each of the aforementioned aspects is typical of aikido, it can be regarded as an excellent representative of recreational physical activity [5].

As aikido does not involve competition and championships (i.e. periods when peak performance is needed), there are no training cycles or periodization in the training schedule. A typical (60- or 90-minute-long) aikido workout starts with a 15 minutes long warming-up period that also includes stretching elements. The rest of the session is practiced in pairs. First, the instructor presents a technique several times, then everyone chooses a partner and they practice the presented technique together, changing the roles of attacker and defender on a regular basis. The major emphasis is put on the technically perfect, fluent, and elegant execution of the techniques, which requires a high level of coordination and balance. The two partners try to achieve a steady state, i.e., an intensity which makes continuous and focused practice possible. After approximately 10-15 minutes of practicing, another technique is presented and a different partner is chosen. As aikido practitioners show considerable differences with respect to age (from the age of about 15 to 80 years), gender, and various aspects of fitness, the actual training load and its components (endurance, strength, etc.) also change with every partner. In other words, the actual training load is always determined by the technique and the partner.

Theoretically, aikido workouts, when performed on a regular basis (i.e. 2-3 times 60-90 minutes a week), can fit the recent recommendations of the American College of Sports Medicine (ACSM) [6] with respect to the optimal amount of moderate and vigorous intensity cardio-respiratory load, and exercises targeting flexibility, balance, and coordination. Resistance exercise, however, is not a component of typical aikido bouts.

The scientific evidence concerning the above mentioned health protective characteristics of aikido is scarce [7]. There was only one study on the cardiovascular load of aikido workouts [8] with the conclusion that aikido is not an aerobic exercise. A few studies were conducted to shed more light on the fitness characteristics of aikido practitioners. In one research [9], isokinetic strength of the wrist was measured. According to the results, aikido practitioners had weaker hand grip strength than other martial arts and combat sports athletes (e.g. practitioners of judo or wrestling), however, showed no differences between left and right hand. Concerning anthropometric characteristics, they showed no differences compared to a non-athlete population [10]. Beginners were characterized by better body fat and BMI values than advanced practitioners in another study [11], however age was not controlled for in these two studies. Aikido practice was associated with a larger flexibility of the upper extremities than other sports (e.g. tennis and baseball) [12]. Moreover, a number of well-conducted studies revealed positive effects of aikido practice on scoliosis [13-15], balance stability [16, 17], and functional efficiency [18].

In the present research, with respect to participants, it was expected that regular aikido practice will be associated with improved cardiovascular fitness, and anthropometric and flexibility characteristics. Finally, we assumed no improved strength for and no difference between the grip strength of the two hands in the aikido group.

Our study aims is knowledge about the cardiovascular load of traditional aikido workouts, and various aspects of aikido practitioners' fitness.

MATERIAL AND METHODS

Participants

Participants (n = 38, mean age 36.3 ±9.28 yrs, ranging from 18 to 52 years) were male aikido practitioners recruited from the Hungarian Aikido Federation. The average duration of participants' aikido practice was 11.9 ±6.86 years; they spent about three hours a week (±1.24 hours) with aikido exercise, the average weekly number of bouts was 2.0 ±0.85. Concerning participants' rank, 28.9% were beginners (up to third kyu), 18.4% were on the intermediate (second and first kyu) and 52.6% on the advanced level (dan holders). Additional sports were exercised by 60.5 % of the participants, with a mean of 1.8 ±1.95 hour/week exercise.

The study was approved by the Institutional Ethics Board of Eötvös Loránd University. All participants read and signed an informed consent form before completing the measurements.

Design and procedure

A maximal oxygen uptake (VO_2max) measurement was conducted to estimate cardiovascular capacity and anaerobic threshold. A spiroergometer (Cosmed Fitmate Med, Cosmed The Metabolic Company, Italy) and a cycle ergometer (Ergo Bike Premium8, Daum Electronic, Germany) were used to measure oxygen consumption during exercise. We conducted a maximal graded exercise test. After a short warp-up period (subjects cycled for 3 min at minimum resistance, i.e. 20 Watt/min), the resistance of the ergometer increased in 25 Watt/min increments until the subject reached his or her limit of tolerance. The pedal rate was maintained at 80 ±5 rpm throughout the test (i.e. if the pedal rate dropped permanently under 75 rpm, the test was finished). Subjects were verbally encouraged to provide a true maximal effort. During the test protocol, ventilation, O_2 consumption (VO_2), and heart rate (HR) were simultaneously measured.

Body composition. The Omron BF511 (Omron Healthcare Co., Japan) body composition monitor was used to measure body weight, body fat percent, and skeletal muscle percent. Body height was measured manually.

Hand grip. Maximal static grip strength (kg) measures were collected for both hands with a hand grip dynamometer (EH101, Deyard, China). Maximal grip scores were converted to Newtons, and normalized to body mass.

Lateral side bending flexibility. Trunk flexibility was measured with the *lateral side-bending test* (EUROFIT). The test measures the range of movement in lateral flexion of the thoracic and lumbar spine and pelvis. For each individual, the mean of the right-side and left-side performance was calculated.

Sit and reach flexibility test (EUROFIT) was carried out to measure the flexibility of the lower back and hamstring muscles.

Heart rate (HR). Continuous heart rate measurements were carried out during regular aikido workouts (90 minutes; a minimum of 3 bouts/person), with the Firstbeat TeamBelt system (Firstbeat Technologies Ltd., Jyväskylä, Finland). The system uses a chest belt attached to the ribcage under the *musculus pectoralis major*, and contains two built-in electrodes and a wireless unit that transmits data in real time to a receiver connected to a computer. Data were analysed using a dedicated software (Firstbeat Sports v4.7.2.1) [19]. The software estimates energy expenditure and excess post-oxygen consumption (EPOC) from measured HR taken into consideration individual anthropometric characteristics and VO_2max.

Training zone. To establish training heart rate zones, individual anaerobic thresholds were estimated from the spiroergometric data obtained from the maximal graded exercise test. For each person, actual oxygen consumption and

practice the product of effort duration and HR was referred to as conventional units' or further calculations have been made to convert it into points." [31, p. 238].

Anaerobic threshold – ***noun*** same as **onset of blood lactate accumulation** [30].

Threshold – ***noun*** **1.** The point at which something starts, e.g. Where something can be perceived by the body or where a drug starts to have an effect **2.** The point at which a sensation is strong enough to be sensed by the sensory nerves [30].

Maximal oxygen consumption – ***noun*** same as **VO2Max** [30].

Training zone – ***noun*** the heart rate range within which a person should aim to exercise for maximum effect [30].

Training session – ***noun*** a period of time during which an athlete trains, either alone, with a trainer or with their team [30].

ventilation were used to calculate the ventilatory (anaerobic) threshold. Threshold was estimated as the point at which ventilation started disproportionately increase compared to oxygen uptake. This break point was determined by the consensus of three experts. Experts considered the results of an algorithm written in Matlab to detect break point and also the slope of the ventilation-oxygen consumption curve. The detection algorithm implements the sixth method described in the paper of Ekkekakis and colleagues [20], i.e., the breakpoint was determined on the [VE/VO_2 vs. VO_2] diagram by the statistical method of Jones and Molitoris [21]. Using the calculated anaerobic VO_2 threshold values, the corresponding anaerobic HR threshold values were obtained from the [HR vs. VO_2] diagram by another Matlab program (the custom algorithms are available upon request). Finally, two training zones were calculated with the use of the individual anaerobic HR for each participant. First, "*anaerobic exercise zone*" was considered the HR zone above the anaerobic HR threshold. Second, following the practice and recommendations of ACSM [6] *"aerobic exercise zone"* was defined and calculated as the range between HR corresponding to 0.4 x (VO_2max – VO_2resting) and the anaerobic HR threshold. Then the average percentage values of time spent in the two zones were calculated for each participant (Figure 1).

Fitness measurements were taken at a 1 week long aikido training camp in summer 2017, in the following order for each participant: body

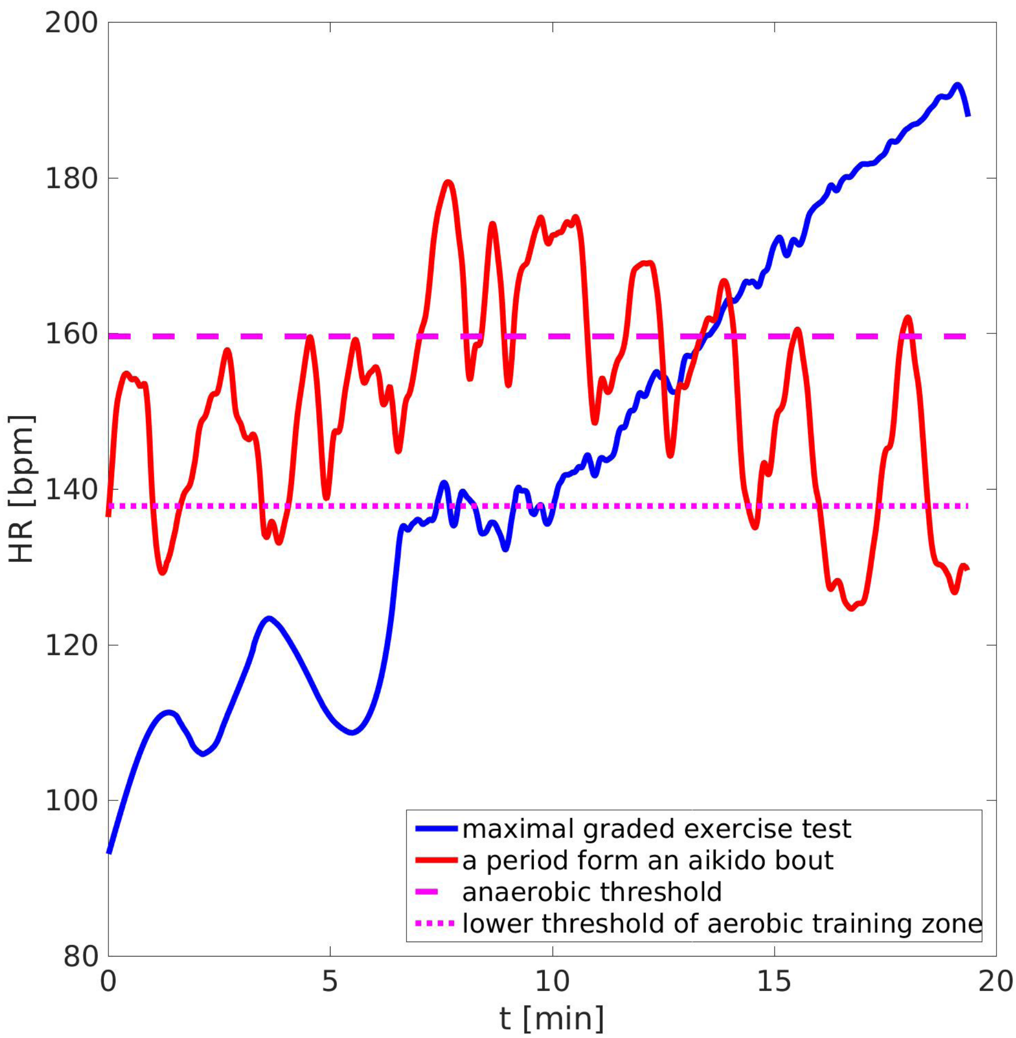

Figure 1. Changes in HR during the graded exercise test and a typical aikido workout (31 years old male aikido practitioner).

Table 1. Descriptive statistics of the aikido workouts (n = 30).

Variable	Mean, SD
heart rate (beat×minute^{-1})	116.6 ±13.45
estimated energy expenditure (kcal)	607.2 ±164.30
EPOC (ml×kg^{-1})	38.0 ±31.92
aerobic zone (%)	35.2 ±17.34
anaerobic zone (%)	16.5±18.43

EPOC: excess post-oxygen consumption.

composition, hand grip strength, lateral side bending flexibility, sit and reach test, and VO_2max measurement. HR measurements were carried out in different seasons of the year 2016/2017 (usually once every month) during 90 minutes long training sessions. HR related data were missing for 8 participants due to technical difficulties.

Statistical analysis

Statistical analysis was conducted using the JASP v0.8.5.1 software. Measured value of each measured variable (maximal oxygen uptake, body fat percent, skeletal muscle percent, body mass index) of each individual was compared to the age and gender adjusted mean value of a non-representative Hungarian sample that consisted of physically inactive men [22, 23]. In the absence of appropriate Hungarian reference values, measured values for grip strength, sit and reach test, and lateral side bending were compared to the respective reference values of the EUROFIT [24]. Delta values were calculated by subtracting the respective reference value from the measured value then dividing by the reference value (Δ = (measured – reference) / reference). If Shapiro-Wilk test indicated no deviation from normality, one-sample t-test was used to check the deviation of the delta value from zero. If the normality assumption was violated, Wilcoxon-test was used. Grip strengths of the two hand were compared with paired-samples t-test. Effect sizes (ES) were Cohen's d values for t-tests, and matched rank-biserial correlations for the Wilcoxon-test.

According to the results of *a priori* sample size calculation for one-tailed one-sample t-test, assuming an alpha value of 0.05, a power (1-beta) of 0.90, and a medium effect size of 0.5, the minimum acceptable sample size is 36 (G*Power v. 3.1.9.2) [25].

RESULTS

Participants spent approximately one third of the total training time in the aerobic domain and about 16% in the aerobic domain (Table 1).

Variables describing aikido practitioners' fitness and their calculated deviations from the respective reference value are summarized in Table 2.

Normalized grip strength: maximal grip scores converted to Newtons, and normalized to body mass.

Concerning maximum oxygen uptake, the aikido group showed a significantly better mean value than the reference value (t-test: t_{37} = 3.352; p = 0.002, ES = 0.544). Average grip strength of the aikido group was worse than that of the reference value (t-test: t_{37} = −3.648; p<0.001, ES = −0.592). No difference between the grip strength of the two hands was found (t-test: t_{37} = 0.726; p = 0.473, ES = 0.118). As for flexibility, lateral side bending values were better in the aikido group than the reference values (t-test: t_{37} = 4.433; p<0.001, ES = 0.719), while sit and reach values were worse (t-test: t_{37} = −6.175; p<0.001, ES = −1.002). Anthropometric measurements showed a smaller average BMI (Wilcoxon statistic = 220.0; p = 0.030, ES = −0.406) and marginally smaller body fat percent (t-test: t_{37} = −1.804; p = 0.079, ES = −0.293), but also a smaller body muscle percent (Wilcoxon statistic = 77.00; p<0.001, ES = −0.792) for aikido practitioners than the reference value.

DISCUSSION

The present study represents the first attempt to directly measure the cardiovascular load of traditional aikido workouts (Figure 2). During aikido bouts, participants spent in average 35% of their

Table 2. Descriptive statistics of male aikido practitioners' fitness and anthropometric characteristics and their deviation from the respective reference values (n = 38).

Variable	Mean, SD
anaerobic threshold (beat $\times$ minute^{-1})	137.2 ±26.62
lower threshold of the aerobic training zone (beat $\times$ minute^{-1})	110.9 ±17.09
VO2max (ml$\times$kg^{-1} $\times$ min^{-1})	38.1 ±7.79
ΔVO2max (ml$\times$kg^{-1} $\times$ min^{-1})	0.1 ±0.19
normalized grip strength (N $\times$ kg^{-1}); dominant hand	6.3 ±1.16
Δnormalized grip strength (N $\times$ kg^{-1})	–0.1 ±0.16
grip strength (kg; right hand)	50.4 ±7.65
grip strength (kg; left hand)	46.4 ±8.37
lateral side bending (cm)	23.9 ±4.48
Δlateral side bending (cm)	0.2 ±0.21
sit and reach (cm)	24.5 ±9.23
Δsit and reach (cm)	–0.3 ±0.27
BMI (kg$\times$m^{-2})	25.6 ±4.06
ΔBMI (kg$\times$m^{-2})	–0.0 ±0.15
body fat (%)	18.7 ±6.50
Δbody fat (%)	–0.1 ±0.36
muscle (%)	39.8 ±4.47
Δmuscle (%)	–0.1 ±0.11

time in the aerobic and 16% in the anaerobic training heart rate zone. Compared to the respective reference group, individuals practicing aikido on a regular basis were characterized by better VO_2max, BMI, body fat, and lateral side bending values; however, they were inferior with respect to the sit and reach test, body muscle percent and hand grip strength.

Our findings concerning the cardiovascular load represented by aikido workouts were contradictory to the conclusion of Jasnoski et al. [8], namely, that aikido is not an aerobic exercise. We found that one third of the time (i.e., more than half an hour during a 90-minute-long bout) is spent in the aerobic pulse zone. Moreover, the aikido group showed better cardiovascular fitness (VO_2max) than the matched reference value. It is important to mention, that, unlike Jasnoski et al. [8] who draw their conclusion from measuring pulse rates immediately after the training sessions, we applied a more advanced measurement method (i.e. continuous heart rate monitoring during training sessions), and also took into account individual anaerobic thresholds. According to our results, regular (2-3 bouts/week) aikido training does represent a considerable aerobic cardiovascular load, which has positive long-term cardiovascular effects.

Regarding body composition, our findings are more positive for aikido practitioners (i.e. lower BMI and body fat percent), than those reported by Reguli et al. [10]. This difference can be explained mostly by the poor health status (e.g. adult obesity rates are among the highest in the world [26]) of the Hungarian population reflected by the reference values, as the reported average body fat value of the Czech aikido sample was even a little lower than that of the Hungarian. Moreover, the Reguli et al. [10] study did not take into consideration age related differences in body composition.

Concerning strength related findings, our aikido group showed a lower body muscle percent and less grip strength than the reference values. The weaker hand grip of aikido practitioners appears to characterize aikido not just in comparison to other martial arts and combat sports, as reported in the Vodicka at al. [9] study, but also compared to reference values. These findings indicate that traditional aikido training does not enhance

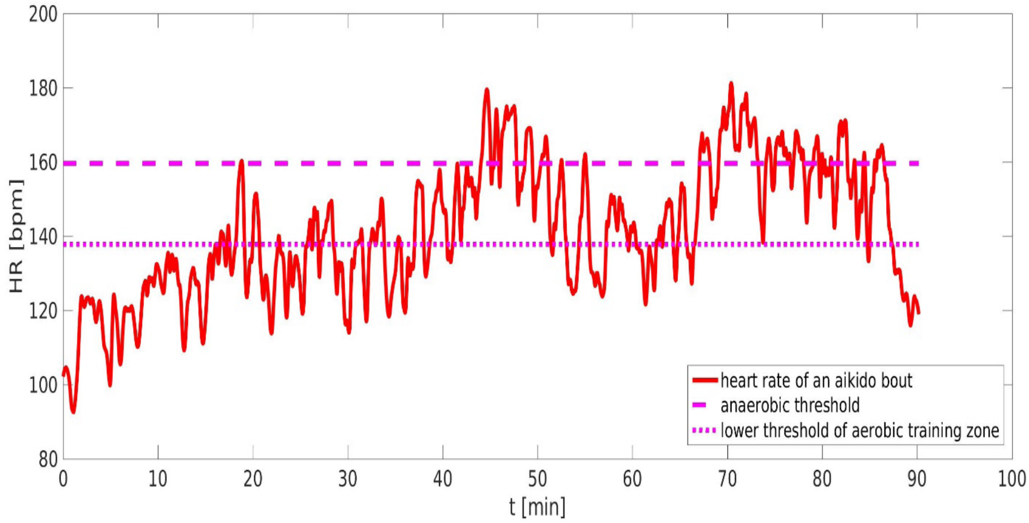

Figure 2. Heart rate recording of a typical aikido workout (Firstbeat Sports software; 31 years old male aikido practitioner).

muscle strength. This result seems to be in accordance with the basic philosophy of aikido, i.e., not using force against force [27]. Still, from a health promotion point of view, this characteristic is not desirable thus muscle power should be enhanced by additional exercises.

In accordance with the results of Vodicka et al. [9], we found no differences between the strength of the two hands. This is mostly valid for other martial arts as well (see Vodicka et al. [9]). In aikido practice, the techniques are always practiced on both side of the body equally, so both hands are loaded to the same extent.

As of flexibility, the positive effect of aikido training on the flexibility of the upper extremities was already shown by Huang et al. [12]. In our present study, we aimed to investigate flexibility of the medium and lower part of the body. Aikido practitioners were better in the lateral flexion of the thoracic and lumbar spine and pelvis (as assessed by the lateral side bending test) than the reference values, and worse in flexibility of the lower back and hamstring muscles (sit and reach test).

Overall, our results demonstrate that traditional aikido bouts exercised on a regular basis (i.e. 90 minutes 2-3 times a week), are in accordance with ACSM recommendations [6] for moderate-intensity cardio-respiratory exercise training.

ACSM also recommends exercises to improving balance and coordination. Empirical findings [16, 17] demonstrate that aikido practice results in better balance stability. According to ACSM recommendations, flexibility exercises for each of the major muscle–tendon groups is also an important part of health. Aikido seems to enhance flexibility of the upper extremities and thoracic and lumbar spine and pelvis, but not of the lower back and hamstring muscles.

In conclusion, recreational aikido practice exercised 2-3 times a week for 90 minutes suit the ACSM recommendations with the exception of resistance training. To improve muscle strength, additional exercises are necessary.

By considering the health effects of aikido we should also take into account the possibility of injuries. According to Zetaruk et al. [28], aikido practice is associated with a higher risk of head/neck, upper extremity, and soft tissue injury compared with karate practitioners. The adequate measurement of the possibility of injuries caused by aikido training is an important task for future studies.

CONCLUSIONS

Aikido represents a recreational exercise with considerable health protective effects. To maximize its beneficial effects, however, additional emphasis on resistance training and the avoidance of injuries are needed.

LIMITATIONS

An important limitation of our study is that neither the aikido group nor the Hungarian reference values were representative of the respective populations. Also, as national reference values were not available for a number of fitness tests, we had to use the EUROFIT as reference in several cases. Finally, possible effects of other sports practiced by the participants were not taken into consideration.

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REFERENCES

1. Aikikai Foundation. About Aikido [Internet] 2017 [accessed 2018 Jul 3]. Available from: URL:http://www.aikikai.or.jp/eng/aikido/about.html
2. Ueshiba K. The spirit of aikido. 1st ed. Tokyo; Kodansha International; 1984
3. Stevens J. The Philosophy of Aikido. Distributed in the U.S. By Kodansha America; 2001
4. Rogers HE. Development of a recreational exercise motivation questionnaire [Internet] [PhD thesis]. Victoria University of Technology; 2000 [accessed 2018 Jul 3]. Available from: URL:http://www.vu.edu.au/research
5. Berger BG, Pargman D, Weinberg RS. Foundations of Exercise Psychology. 2nd ed. Morgantown: Fitness Information Technology; 2007
6. Garber CE, Blissmer B, Deschenes MR et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011; 43(7): 1334-1359
7. Szabolcs Z, Köteles F, Szabo A. Physiological and psychological benefits of aikido training: a systematic review. Arch Budo 2017; 13: 271-283
8. Jasnoski ML, Cordray DS, Houston BK et al. Modification of Type A behavior through aerobic exercise. Motiv Emot 1987; 11(1): 1-17
9. Vodicka T, Pieter W, Reguli Z et al. Isokinetic strength of the wrist in male aikido athletes. Ido Mov Cult J Martial Arts Anthropol 2016;16(2): 48-54
10. Reguli Z, Bernaciková M, Kumstát M. Anthropometric Characteristics and Body Composition in Aikido Practitioners. Int J Morphol 2016; 34(2): 417-423
11. Bernaciková M, Reguli Z, Kumstát M. Somatotypes of different levels in Czech aikidokas. 7th International scientific conference on kinesiology Fundamental and applied kinesiology – steps forward; 2014 May 22-25; Opatija, Croatia
12. Huang C-C, Yang Y-H, Chen C-H et al. Upper Extremities Flexibility Comparisons of Collegiate "Soft" Martial Art Practitioners with Other Athletes. Int J Sports Med 2008; 29(3): 232-237
13. Mroczkowski A, Jaskólski E. Effects of aikido exercises on lateral spine curvatures in children. Arch Budo 2006; 2: 31-34
14. Mroczkowski A, Jaskólski E. The change of pelvis placement at children under influence of aikido training. Arch Budo 2007; 3: 21-26
15. Mroczkowski A. The effect of aikido exercises on shaping spinal curvatures in the sagittal plane. J Combat Sports Martial Arts 2013; 4(2): 173-177
16. Bazanova OM, Kholodina NV, Podoinikov AS et al. Stabilometric, electromyographic, and electroencephalographic parameters in postmenopausal women depend on training support afferentation. Hum Physiol 2015; 41(4): 386-393
17. Bazanova OM, Kholodina N v., Nikolenko E d. et al. Training of support afferentation in postmenopausal women. Int J Psychophysiol 2017; 122: 65-74
18. Boguszewski D, Suchcicka B, Grzegorz Adamczyk J et al. The functional efficiency and incidence of injuries in men practicing aikido. Pilot study. J Combat Sports Martial Arts 2013; 4(1): 67-73
19. Firstbeat Technologies Ltd. Firstbeat Lifestile Assassement Specialist Manual. Jyväskylä, Finland; 2014
20. Ekkekakis P, Lind E, Hall EE et al. Do regression-based computer algorithms for determining the ventilatory threshold agree? J Sports Sci 2008; 26(9): 967-976
21. Jones RH, Molitoris BA. A statistical method for determining the breakpoint of two lines. Anal Biochem 1984; 141(1): 287-290
22. Ihász F, Boros P, Szabó P et al. Age-dependent aerobic capacity among young and middle-aged males. Gazz Med Ital 2016; 175(3): 68-75
23. Ihász F, Finn KJ, Lepes J et al. Body Composition Comparisons by Age Groups in Hungarian Adults. Int J Morphol 2015; 33(3): 850-854
24. Olja P, Tuxworth B. Eurofit for Adults: Assessment of Health-Related Fitness. Finland: Council of Europe Publishing; 1995
25. Faul F, Erdfelder E, Lang A-G et al. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007; 39(2): 175-191
26. OECD. Obesity Update 2017 [Internet]. Paris: OECD; 2017. [accessed 2018 Jul 3]. Available from: URL:http://www.oecd.org/health/obesity-update.htm
27. Shishida F. Why can a little lady throw down a strong man using only a finger? The mechanism of soft *atemi-waza*. In: Kalina RM, editor. Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach; 2015 Sep 17-19; Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 49-58
28. Zetaruk MN, Violán MA, Zurakowski D et al. Injuries in martial arts: a comparison of five styles. Br J Sports Med 2005; 39(1): 29-33
29. Budō: The Martial Ways of Japan. Tokyo: Nippon Budokan Foundation; 2009
30. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
31. Kalina RM. Methodology of measurement, documentation and programming optimal workload continuous with variable intensity – applications in sports medicine, physiotherapy, geriatrics, health-related training, sport for all. Arch Budo 2012; 8(4): 235-24

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