

# Contact Karate Promotes Post-Exercise Hypotension in Young Adult Males

Marcelo Magalhaes Sales,<sup>1,2,\*</sup> Caio Victor de Sousa,<sup>1</sup> Wellington Barbosa Sampaio,<sup>1</sup> Carlos Ernesto,<sup>1</sup> Rodrigo Alberto Vieira Browne,<sup>3</sup> Jose Fernando Vila Nova de Moraes,<sup>4</sup> Daisy Motta-Santos,<sup>5</sup> Milton Rocha Moraes,<sup>1</sup> John Eugene Lewis,<sup>6</sup> Herbert Gustavo Simões,<sup>1</sup> and Francisco Martins da Silva<sup>3</sup>

<sup>1</sup>Programa de Pós-Graduação Stricto Sensu em Educação Física, Universidade Católica de Brasília, Distrito Federal, Brazil

<sup>2</sup>Escola da Saúde, UDF-Centro Universitário, Brasília, Brazil

<sup>3</sup>Faculdade de Motricidade Humana, Universidade de Lisboa, Lisboa, Portugal

<sup>4</sup>Faculdade de Educação Física, Universidade Federal do Vale do São Francisco, Pernambuco, Brazil

<sup>5</sup>Departamento de Fisiologia e Biofísica, Universidade Federal de Minas Gerais, Minas Gerais, Brazil

<sup>6</sup>Department of Psychiatry and Behavioral Sciences, University of Miami Miller School of Medicine, Miami FL, USA

\*Corresponding author: Marcelo Magalhaes Sales, Programa de Pós-Graduação Stricto Sensu em Educação Física, Universidade Católica de Brasília, EPTC, QS07, LTI s/n. Bloco G, Sala 15, CEP 72030-170 Aguas Claras, Brazil. Tel: +55-6133569350, Fax: +55-6133569350, E-mail: marcelomagalhaessales@gmail.com

Received 2015 October 15; Revised 2015 December 15; Accepted 2016 January 16.

## Abstract

**Background:** Worldwide, systemic arterial hypertension is a leading cause of death and non-communicable cardiovascular disease. A major factor contributing to this disease is a sedentary lifestyle. However, physical exercise, such as martial arts, may be an option for blood pressure (BP) control. The magnitude of post-exercise hypotension is associated with a prolonged decrease in BP in normotensive and hypertensive individuals.

**Objectives:** The present study aimed to verify the effects of a Contact Karate (CK) session on BP responses during a post-exercise recovery period in young adults.

**Patients and Methods:** Thirty-two male CK athletes volunteered ( $28.2 \pm 6.7$  years;  $77.0 \pm 5.7$  kg; and  $176.0 \pm 4.7$  cm) and underwent one CK session (50 minutes) and a control session in which no exercise was performed and the individuals remain seated during the whole time. BP was measured during rest (before sessions), as well as on the 15th, 30th, 45th, and 60th minutes of the post-exercise recovery.

**Results:** The systolic (SBP), diastolic (DBP), and mean arterial pressure (MAP) were significantly lower at the post-exercise period compared to pre-exercise rest ( $P < 0.05$ ), with the largest reductions being observed at the 60th minutes of recovery [SBP (rest:  $125.9 \pm 4.7$  vs. 60th minutes of recovery:  $111.7 \pm 5.4$  mmHg); DBP (rest:  $78.8 \pm .7$  vs. 60th minutes of recovery:  $69.8 \pm 2.7$  mmHg)] and at the same periods of post-exercise recovery of the control session.

**Conclusions:** A single CK session can promote a decrease in BP for at least 60 minutes after performing this type of exercise in young adults.

**Keywords:** Martial Arts, Blood Pressure, Cardiovascular Benefits, Fighting Sports, Health Promotion

## 1. Background

Currently, cardiovascular disease is the leading cause of death worldwide among all non-communicable disease (17.5 million deaths or 46%) (1) with systemic arterial hypertension (SAH) being the main cause (2). It is estimated that about 1.5 billion people (22%) are hypertensive (1). In Brazil last year, the cost of treatment of SAH was \$9 million, according to the Brazilian public health service database (3).

Modifiable factors that contribute to the high prevalence rates of SAH are eating food containing too much salt and fat, overweightness and obesity, and physical in-

activity (1). On the other hand, studies have highlighted that a single session of exercise can reduce blood pressure (BP) to below resting values in the elderly (4), individuals with diabetes (5-8), and both hypertensive (9) and normotensive (10) individuals. This phenomenon is known as post-exercise hypotension (PEH). Moreover, some studies demonstrated that the magnitude of PEH is associated with a long-lasting decrease in BP in normotensive and hypertensive individuals (10-12), supporting that exercise can be a protective factor against the development of SAH. This, for instance, justifies the investigation of post-exercise BP response on normotensive individuals. Furthermore, the

post-exercise BP response has been frequently used for the detection and prediction of coronary artery disease and arterial hypertension (13-15), highlighting the importance of post-exercise BP measurements regardless of the studied population.

Several studies have investigated the effects of different exercise modes (e.g. aerobic vs. resistance) (6), intensities (4), and durations (16) on BP responses during the post-exercise recovery period. Studies regarding the effects of different sports modalities, especially martial arts, have also been performed, such as: Tai Chi Chuan (TCC) (17, 18), jiu jitsu (19), and judo (20) However, only Simao et al. (20) and Lu and Kuo (18) investigated the effects of a single judo and TCC session on post-exercise BP responses. Until now, no study has explored the BP responses after a single Contact Karate (CK) session, which appears to have distinct physiological characteristics compared to the aforementioned modalities (21, 22). For example, CK is more dynamic and has movements performed at higher speed.

Moreover, Mynarski et al. (23) showed that CK created higher energy expenditure compared to all combat sports investigated, and it caused higher energy expenditure that was associated with lower resting BP (24, 25). Thus, it is reasonable to infer that CK seems to be the most effective of all combat sports in reducing BP. In addition, it is estimated that approximately 1 million people practice CK in Brazil, and more than 20 million practice it throughout the world (26, 27), suggesting that this form of exercise may prevent SAH.

It is worth mentioning that the scientific literature related to combat sports has hardly been explored, especially regarding health-related variables (i.e. post-exercise BP reduction). Most studies have investigated performance-related parameters in athletes, making the evaluation of health-related variables (such as PEH) a scientific gap. Therefore, investigations related to this issue have been strongly encouraged (28).

Furthermore, the prescription of combat sports either as prophylactic or therapeutic purposes is still based on practical experience rather than on scientific evidence. Much of what is hypothesized about this subject is based on studies using other exercise modes, such as aerobic or resistance training, and the conclusions are often extrapolated to various sports, keeping the literature (for researchers and combat sports enthusiasts) lacking in depth. Thus, exercise physiologists at all educational levels, scientists whose research focuses on BP response to exercise, and persons interested in martial arts may benefit from this research.

## 2. Objectives

Given the previous findings, the purpose of this study was to assess the effects of a single CK session on post-exercise BP responses in young adults. We hypothesized that CK could be effective in promoting PEH.

## 3. Patients and Methods

### 3.1. Sample

After approval from the research ethics committee of the Catholic University of Brasilia (approval n. 198/2010) and signing of the informed consent form, 32 adult males participated in the study. The average age of the subjects was  $28.2 \pm 6.7$  years, the average weight was  $77.0 \pm 5.7$  kilogram, the average height was  $176.0 \pm 4.7$  centimeter, and all participants had at least 6 months of CK practice. Criteria for participation in the study included: A, between 18 and 35 years of age; B, having at least 6 months of CK practice; C, not having any kind of bone, muscle, or joint injury that would preclude performing the experimental sessions; D, membership as an athlete in the Okikukai Uechiryu Brazil, Aguas Claras, Distrito Federal; and E, experience in state-level competitions.

### 3.2. General Procedures

After a clinical evaluation and medical history performed by a cardiologist, the volunteers were instructed to not perform any kind of exercise throughout the duration of the study and not to ingest alcoholic beverages and caffeine in the 24 hours prior to the experimental sessions. The experiment consisted of two training sessions (i.e. CK session and control session (CON)) performed in a randomized order at the same time of day with an interval of 48 hours between sessions. The sessions were performed in a temperature and humidity controlled environment ( $18^{\circ}\text{C}$  to  $22^{\circ}\text{C}$  and 50% to 70%, respectively).

### 3.3. Contact Karate Session

Initially, to measure BP at rest (Microlife BP 3AC1-1) and heart rate (HR) (Polar FS1), the volunteers remained seated for 20 minutes with their legs uncrossed, feet touching the floor, back relaxed and supported on the chair, arms positioned at the same height of the heart (at the medium point of the sternum or fourth intercostal space), free of clothes, with their palms facing upwards and elbows slightly flexed, as previously described (21). After rest, the volunteers practiced a 50 minutes session of CK. HR was monitored throughout the whole session. BP data regarding the post-exercise recovery period was collected at each fifteen minutes during a one-hour period.

The CK session was divided in four stages: A, from the 1st to the 10th minutes, where the volunteers performed a warm-up that consisted of calisthenics and relaxed punching and front-kicking (without tension); B, from the 11th to the 30th minutes, in which the CK techniques were conducted (punching and kicking) with the volunteers pairing with a colleague; C, from the 31st to the 60th minutes, where a CK fight (Kumite) was performed, with the volunteers alternating among each other; and D, the 60 minutes post-exercise recovery period, in which BP was measured at each 15 minutes.

### 3.4. Control Session

During the CON session the volunteers had the same measurements as in the CK session. However, no exercise was performed and the individuals remained seated during the whole time.

### 3.5. Statistical Analysis

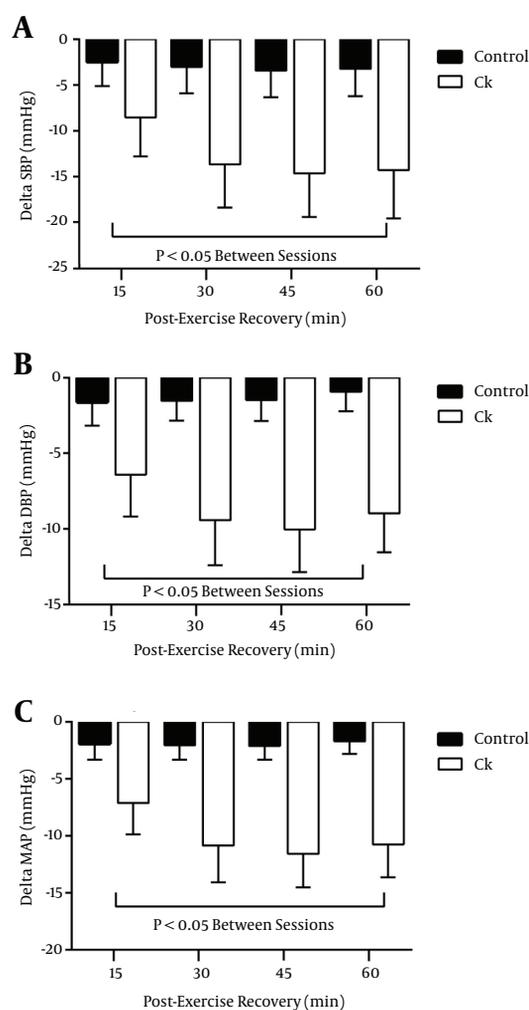
A priori, statistical power of 95% was calculated for the study, considering the statistical model used (split-plot ANOVA), an effect size of  $F = 0.25$ , two sessions (CK and CON), five repetitions (rest and 15th, 30th, 45th, and 60th minutes of the post-exercise recovery period), and  $\alpha = 0.05$ . Normality and homogeneity were analyzed using the Shapiro-Wilk and Levene's tests, respectively. Data were expressed in mean ( $\pm$ ) standard deviation. To compare values between and within groups, a split-plot ANOVA was performed with Scheffe's procedure post-hoc. In case any of the dependent variables did not have sphericity according to the Mauchly's test, the Greenhouse-Geisser's  $\epsilon$  degrees of freedom correction was used to analyze the F statistics. The level of significance utilized was  $P \leq 0.05$ . All data were analyzed using SPSS 15 for Windows (IBM, Inc., Chicago, IL, USA).

## 4. Results

In response to the single CK session, SBP, DBP, and MAP were significantly lower during the post-exercise recovery period compared to pre-exercise rest (Table 1) and when compared to the same periods of the CON session (Table 1 and Figure 1). It is noteworthy that the CK session would be considered high-intensity exercise (29), as it was performed with average HR of  $174.2 \pm 5.8$  b/min, which represents  $90.9 \pm 4.7\%$  of the participants' maximal HR.

## 5. Discussion

The purpose of this study was to assess the effects of a single CK session on post-exercise BP responses in



**Figure 1.** Delta Values of SBP, DBP, and MAP During Post-Exercise Recovery Periods (Rec) in CK and CON

young adults. This topic is important, as the scientific literature related to combat sports has hardly been explored, especially regarding health-related variables (i.e. post-exercise BP reduction). Most studies have investigated performance-related parameters in athletes, making the evaluation of health-related variables (such as PEH) a scientific gap, but important for future research (28). Thus, this information is unique and can be applicable for combat sports and programs for prevention of hypertension.

The results of the present study indicated that a single CK session was effective in promoting PEH in young normotensive adults. This disagrees with Simao et al. (20) in which 12 hypertensive judo students practiced a training session and showed no significant BP reductions in the

**Table 1.** Mean Absolute Values of SBP, DBP, and MAP at Rest and During Post-Exercise Recovery Periods (Rec) in CK and CON (N = 32)

	Rest	Rec15	Rec30	Rec45	Rec60
<b>SBP (mmHg)</b>					
CK	125.9 ± 4.7	117.4 ± 5.6 <sup>a,b</sup>	112.3 ± 5.4 <sup>a,b</sup>	111.3 ± 5.0 <sup>a,b</sup>	111.7 ± 5.4 <sup>a,b</sup>
CON	125.4 ± 2.3	123.9 ± 2.6	123.8 ± 2.8	123.7 ± 2.9	123.8 ± 2.7
<b>DBP (mmHg)</b>					
CK	78.8 ± 2.7	72.3 ± 3.5 <sup>a,b</sup>	69.3 ± 1.8 <sup>a,b</sup>	68.7 ± 1.7 <sup>a,b</sup>	69.8 ± 2.7 <sup>a,b</sup>
CON	78.7 ± 2.6	77.6 ± 2.1	77.7 ± 2.2	77.8 ± 2.2	77.9 ± 2.3
<b>MAP (mmHg)</b>					
CK	94.5 ± 3.1	87.4 ± 3.5 <sup>a,b</sup>	83.6 ± 2.7 <sup>a,b</sup>	82.9 ± 2.4 <sup>a,b</sup>	83.7 ± 3.2 <sup>a,b</sup>
CON	94.1 ± 2.4	92.8 ± 2.9	93.1 ± 2.0	92.9 ± 1.9	93.0 ± 1.9

Abbreviations: CK, Contact Karate Session; CON, Control Session; Rec, Recovery.

<sup>a</sup>P < 0.05 in Relation to Rest.

<sup>b</sup>P < 0.05 vs CON at the Same Moment.

post-exercise recovery period. However, during all periods (10th to 60th minutes of post-exercise recovery) in their study, the SBP and DBP remained visually lower than values at rest, with decreases of 8.6% and 9.3% in SBP and DBP, respectively.

The differences in our findings can be partially explained by the peculiar characteristics of judo training, which presents great upper and lower limb isometry (21). This could favor an increase in peripheral vascular resistance (30) due to blood flow blockage promoted by concentric contractions (31), which can attenuate a hypotensive response induced by exercise. In the Friedman et al. (31) study, for example, leg blood flow was interrupted when a leg extension isometric contraction was performed above 20% of one repetition maximum (RM). Consequently, in this type of exercise, the energy provided for muscle contraction comes predominantly from anaerobic pathways. Therefore, both oxygen uptake and cardiac output increase mildly, which could result in a lower shear stress for this type of exercise, thus attenuating the dilation-induced PEH.

On the other hand, CK is a dynamic exercise mode (22) that may decrease peripheral vascular resistance due to shear stress promoted by the increase in cardiac output. A higher shear stress favors the release of vasodilating substances inducing a BP reduction during the post-exercise recovery period (30).

Another aspect that can explain the differences between the present study and the one performed by Simao et al. (20) is the intensity of the training session, since studies investigating PEH in individuals with diabetes (5-8), normotensive and hypertensive (9), and elderly (4) have suggested that exercises with higher metabolic and hemo-

dynamic stress result in a greater and longer PEH. This happens as the result of a greater mechanical stress, and consequently, a greater release of vasoactive agents (4, 5, 7, 9).

The present study demonstrated that the participants maintained a mean HR of 174.2 ± 5.8 b/min during the CK session, which represents 90.9 ± 4.7% of the maximum HR (HRmax) estimated for their age. Ahmaidi et al. (32), investigating the cardiovascular responses of judo and kendo athletes during combat, found similar or slightly lower HRmax values (89% and 86% for judo and kendo, respectively). This could be one of the causes for the non-occurrence of BP decrease in the Simao et al. (20) study.

However, Lu and Kuo (18) evaluated the effects of a TCC training session on the BP responses of middle-aged (52.8 ± 7.5 years) normotensive individuals (118.4 ± 12.8 mmHg). They demonstrated that TCC promoted PEH, since the volunteers showed significantly lower SBP and MAP values, when compared to rest, at the 30th and 60th minutes of the post-exercise recovery period.

Despite this, the mechanisms surrounding the decrease of BP during the post-exercise recovery period in TCC seem to be different than the one described earlier (4, 33). Other studies have shown that the relative intensity of TCC sessions are 52% and 70% of HRmax (34), which are lower than the values reported by Ahmaidi et al. (32) and of those in the present study. Lu and Kuo (18) suggested that the relaxation induced by TCC can promote PEH through a significant increase in parasympathetic nervous activity, as measured by heart rate variability. They found an increase in the high frequency (HF) indicator, a marker of vagal activity, from 22.8 ± 14.6 to 28.2 ± 16.1 normalized units (nu) in the 30th minutes and to 30.6 ± 18.4 nu in the 60th minutes of the post-exercise recovery period. In addition, the

values of the low frequency/high frequency ratio (LF/HF), an indicator of sympathetic nervous activity, significantly decreased in both the 30th and 60th minutes after exercise.

Once CK requires a high recruitment of motor units, one of the mechanisms that may be involved on PEH is the modulation of the autonomic nervous system through substance P released during muscle contraction. The arousal of the neurokinin-1 receptor during exercise causes it to undergo internalization after exercise, dampening the GABA interneuron's solitary tract nucleus and redefining the baroreflex to a lower level after exercise. This occurs by reducing the transmission to baroreceptor second-order neurons, increasing the excitement of the ventral caudal lateral medulla, increasing inhibition of the rostral ventral lateral medulla, and finally reducing the activity of the autonomic sympathetic nervous system, causing PEH (35). Moreover, as a result of high-intensity exercise inducing shear stress on blood vessels, the release of substances such as nitric oxide and prostaglandins occurs, and in turn may also decrease vascular tone and promote PEH (36, 37). Even though studies have shown the efficiency of martial arts in decreasing BP values after acute sessions (20) and longitudinal training (18), the effects of CK on BP was previously unknown in the literature. Therefore, future studies on the acute and long-term effects of CK on BP responses and the mechanisms involved are necessary, especially in people with hypertension.

The fact that we have not investigated the mechanisms that may be involved in BP reduction after a session of CK can be considered a limitation of this research. Nevertheless, to our knowledge this is the first study that investigated the effects of one CK session on post-exercise BP responses. In addition, these data are important, since it is estimated that approximately 1 million people practice CK in Brazil and more than 20 million practice it throughout the world (26, 27). Therefore, this martial art could be a useful tool for the prevention of SAH.

As a practical application, the results of the present study suggest that CK can be used as an alternative method for the prevention of hypertension. In addition, formal programs of physical exercise (aerobic and resistance) still have a high frequency of non-adherents (~ 45%), and lack of motivation is one of the main reasons (38). Thus, alternative methods of physical exercise, such as martial arts, may be an option, by producing an important social interaction environment, creating a motivating and longstanding atmosphere. Therefore, it is suggested that karate coaches create this atmosphere, allowing greater adherence by its practitioners, taking advantage of this situation constantly.

### 5.1. Conclusion

We found that a single session of CK was effective in reducing BP in young normotensive adults and that this BP reduction may last for at least 60 minutes after exercise. These findings suggest that this martial art may be useful for prevention of SAH. On the other hand, the effectiveness of CK on BP control for special populations and the possible mechanisms involved need to be investigated. Thus, applying the results of the present study should be done cautiously.

### Acknowledgments

Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) granted the scholarships for undergraduate research level (CNPq), MSc (CAPES), PhD (CNPq), and of productivity in research (CNPq).

### Footnotes

**Authors' Contribution:** Marcelo Magalhaes Sales, Caio Victor de Sousa contributed equally to this work. Study concept and design, Sales, Sampaio and Silva; acquisition of data, Sampaio, Sales and Silva; analysis and interpretation of data, Sales, Sousa, Ernesto, Browne, Moraes, Motta-Santos and Simões; drafting of the manuscript, Sales, Sousa, Ernesto, Browne, Moraes, Motta-Santos and Simões; critical revision of the manuscript for important intellectual content, Sales, Sousa, Lewis, Browne, Moraes, Motta-Santos and Simões; statistical analysis, Sales and Sousa; administrative, technical, and material support, Simões, Moraes, Lewis and Silva; study supervision, Simões, Lewis and Silva.

**Financial Disclosure:** The authors declare that they have no competing interests.

**Funding/Support:** This work was supported by CNPq and CAPES.

### References

- Mendis S, Davis S, Norrving B. Organizational update: the world health organization global status report on noncommunicable diseases 2014; one more landmark step in the combat against stroke and vascular disease. *Stroke*. 2015;**46**(5):121-2. doi: [10.1161/STROKEAHA.115.008097](https://doi.org/10.1161/STROKEAHA.115.008097). [PubMed: 25873596].
- Hajjar I, Kotchen JM, Kotchen TA. Hypertension: trends in prevalence, incidence, and control. *Annu Rev Public Health*. 2006;**27**:465-90. doi: [10.1146/annurev.publhealth.27.021405.102132](https://doi.org/10.1146/annurev.publhealth.27.021405.102132). [PubMed: 16533126].
- Datasus. Sistema de Informacoes Hospitalares do SUS (SIH/SUS) 2014. Available from: [tabnet.datasus.gov.br/cgi/tabcgi.exe?sih/cnv/tabnet.datasus.gov.br/cgi/tabcgi.exe?sih](http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sih/cnv/tabnet.datasus.gov.br/cgi/tabcgi.exe?sih).

4. Santana HA, Moreira SR, Neto WB, Silva CB, Sales MM, Oliveira VN, et al. The higher exercise intensity and the presence of allele I of ACE gene elicit a higher post-exercise blood pressure reduction and nitric oxide release in elderly women: an experimental study. *BMC Cardiovasc Disord.* 2011;11:71. doi: [10.1186/1471-2261-11-71](https://doi.org/10.1186/1471-2261-11-71). [PubMed: 22136292].
5. Motta DF, Lima LC, Arsa G, Russo PS, Sales MM, Moreira SR, et al. Effect of type 2 diabetes on plasma kallikrein activity after physical exercise and its relationship to post-exercise hypotension. *Diabetes Metab.* 2010;36(5):363-8. doi: [10.1016/j.diabet.2010.03.008](https://doi.org/10.1016/j.diabet.2010.03.008). [PubMed: 20579916].
6. Sales MM, Russo P, Moreira SR, Santana H, Moraes JF, Asano RY. Resistance exercise elicits acute blood pressure reduction in type 2 diabetics. *J Exerc Physiol Online.* 2012;15(9):98-109.
7. Simoes HG, Asano RY, Sales MM, Browne RA, Arsa G, Motta-Santos D, et al. Type 2 diabetes elicits lower nitric oxide, bradykinin concentration and kallikrein activity together with higher DesArg(9)-BK and reduced post-exercise hypotension compared to non-diabetic condition. *PLoS One.* 2013;8(11):80348. doi: [10.1371/journal.pone.0080348](https://doi.org/10.1371/journal.pone.0080348). [PubMed: 24265812].
8. Karoline de Morais P, Sales MM, Alves de Almeida J, Motta-Santos D, Victor de Sousa C, Simoes HG. Effects of aerobic exercise intensity on 24-h ambulatory blood pressure in individuals with type 2 diabetes and prehypertension. *J Phys Ther Sci.* 2015;27(1):51-6. doi: [10.1589/jpts.27.51](https://doi.org/10.1589/jpts.27.51). [PubMed: 25642036].
9. Moraes MR, Bacurau RF, Ramalho JD, Reis FC, Casarini DE, Chagas JR, et al. Increase in kinins on post-exercise hypotension in normotensive and hypertensive volunteers. *Biol Chem.* 2007;388(5):533-40. doi: [10.1515/BC.2007.055](https://doi.org/10.1515/BC.2007.055). [PubMed: 17516849].
10. Liu S, Goodman J, Nolan R, Lacombe S, Thomas SG. Blood pressure responses to acute and chronic exercise are related in prehypertension. *Med Sci Sports Exerc.* 2012;44(9):1644-52. doi: [10.1249/MSS.0b013e31825408fb](https://doi.org/10.1249/MSS.0b013e31825408fb). [PubMed: 22899388].
11. Hecksteden A, Grutters T, Meyer T. Association between postexercise hypotension and long-term training-induced blood pressure reduction: a pilot study. *Clin J Sport Med.* 2013;23(1):58-63. doi: [10.1097/JSM.0b013e31825b6974](https://doi.org/10.1097/JSM.0b013e31825b6974). [PubMed: 22673537].
12. Tibana RA, de Sousa NM, da Cunha Nascimento D, Pereira GB, Thomas SG, Balsamo S, et al. Correlation between acute and chronic 24-hour blood pressure response to resistance training in adult women. *Int J Sports Med.* 2015;36(1):82-9. doi: [10.1055/s-0034-1382017](https://doi.org/10.1055/s-0034-1382017). [PubMed: 25144430].
13. Amon KW, Richards KL, Crawford MH. Usefulness of the postexercise response of systolic blood pressure in the diagnosis of coronary artery disease. *Circulation.* 1984;70(6):951-6. [PubMed: 6149824].
14. Tsuda M, Hatano K, Hayashi H, Yokota M, Hirai M, Saito H. Diagnostic value of postexercise systolic blood pressure response for detecting coronary artery disease in patients with or without hypertension. *Am Heart J.* 1993;125(3):718-25. [PubMed: 8438701].
15. Michaelides AP, Liakos CI, Vyssoulis GP, Chatzistamatiou EI, Markou MI, Tzamou V, et al. The interplay of exercise heart rate and blood pressure as a predictor of coronary artery disease and arterial hypertension. *J Clin Hypertens (Greenwich).* 2013;15(3):162-70. doi: [10.1111/jch.12035](https://doi.org/10.1111/jch.12035). [PubMed: 23458587].
16. Simoes GC, Moreira SR, Kushnick MR, Simoes HG, Campbell CS. Post-resistance exercise blood pressure reduction is influenced by exercise intensity in type-2 diabetic and nondiabetic individuals. *J Strength Cond Res.* 2010;24(5):1277-84. doi: [10.1519/JSC.0b013e318d67488](https://doi.org/10.1519/JSC.0b013e318d67488). [PubMed: 20386125].
17. Tsai JC, Wang WH, Chan P, Lin LJ, Wang CH, Tomlinson B, et al. The beneficial effects of Tai Chi Chuan on blood pressure and lipid profile and anxiety status in a randomized controlled trial. *J Altern Complement Med.* 2003;9(5):747-54. doi: [10.1089/10755303322524599](https://doi.org/10.1089/10755303322524599). [PubMed: 14629852].
18. Lu WA, Kuo CD. The effect of Tai Chi Chuan on the autonomic nervous modulation in older persons. *Med Sci Sports Exerc.* 2003;35(12):1972-6. doi: [10.1249/01.MSS.0000099242.10669.F7](https://doi.org/10.1249/01.MSS.0000099242.10669.F7). [PubMed: 14652490].
19. Gehre JAV, Coelho JMO, Botelho NW, Queiroz JL, Campbell CSG. Aptidão física de alunos do ensino médio praticantes e não praticantes de jiu-jitsu [in Portuguese]. *Revista Brasileira de Ciência e Movimento.* 2011;18(2):76-83.
20. Simao R, de Deus J, Miranda F, Lemos A, Baptista LA. Efeito hipotensivo em hipertensos após uma aula de judo [in Portuguese]. *Fitness & performance journal.* 2007(2):116-20.
21. Brito CJ, Gatti K, Natali AJ, Costa NMB, Silva CHO, Marins JCB. Estudo sobre a influência de diferentes tipos de hidratação na força e potência de braços e pernas de judocas [in Portuguese]. *Fitness perform J.* 2005(5):274-9.
22. Waggenger GT, Boone T, Kasper M, Waggenger AT. Cardiovascular Responses During Karate Exercise Regimen and Treadmill Exercise at Approximately 70% HR Intensity. *J Exerc Physiol Online.* 2007;10(4).
23. Mynarski W, Krolikowska B, Rozpara M, Nawrocka A, Puciato D. The caloric cost of combat sports and martial arts training in relation to health recommendations-initial research. *Arch Budo.* 2013;9(2):127-33.
24. Wareham NJ, Wong MY, Hennings S, Mitchell J, Rennie K, Cruickshank K, et al. Quantifying the association between habitual energy expenditure and blood pressure. *Int J Epidemiol.* 2000;29(4):655-60. [PubMed: 10922341].
25. Ekelund U, Brage S, Franks PW, Hennings S, Emms S, Wareham NJ. Physical activity energy expenditure predicts progression toward the metabolic syndrome independently of aerobic fitness in middle-aged healthy Caucasians: the Medical Research Council Ely Study. *Diabetes Care.* 2005;28(5):1195-200. [PubMed: 15855588].
26. Barreira CRA, Massimi M. A Moralidade e a Atitude Mental no karatê do Pensamento de Gichin Funakoshi [in Portuguese]. *Belo Horizonte.* 2002(2):39-54.
27. de Oliveira DA, Vieira A, Valença MM. Trauma cranio-encefálico e outras lesões em atletas do karatê de alto nível [in Portuguese]. *Neurobiologia.* 2011;74(1):107-14.
28. Bu B, Haijun H, Yong L, Chaohui Z, Xiaoyuan Y, Singh MF. Effects of martial arts on health status: a systematic review. *J Evid Based Med.* 2010;3(4):205-19. doi: [10.1111/j.1756-5391.2010.01107.x](https://doi.org/10.1111/j.1756-5391.2010.01107.x). [PubMed: 21349072].
29. Thompson PD, Arena R, Riebe D, Pescatello LS, American College of Sports M. ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription, ninth edition. *Curr Sports Med Rep.* 2013;12(4):215-7. doi: [10.1249/JSR.0b013e31829a68cf](https://doi.org/10.1249/JSR.0b013e31829a68cf). [PubMed: 23851406].
30. Brum PC, Tinucci T, Negrao CE. Adaptações agudas e crônicas do exercício físico no sistema cardiovascular [in Portuguese]. *Rev Paul Educ Fis.* 2004;Aug(18):21-31.
31. Friedman DB, Peel C, Mitchell JH. Cardiovascular responses to voluntary and nonvoluntary static exercise in humans. *J Appl Physiol (1985).* 1992;73(5):1982-5. [PubMed: 1474075].
32. Ahmaidi S, Portero P, Calmet M, Lantz D, Vat W, Libert JP. Oxygen uptake and cardiorespiratory responses during selected fighting techniques in judo and kendo. *Sports Med.* 1999;9(2):129-39.
33. Lima LC, Assis GV, Hiyane W, Almeida WS, Arsa G, Baldissera V, et al. Hypotensive effects of exercise performed around anaerobic threshold in type 2 diabetic patients. *Diabetes Res Clin Pract.* 2008;81(2):216-22. doi: [10.1016/j.diabres.2008.04.019](https://doi.org/10.1016/j.diabres.2008.04.019). [PubMed: 18571267].
34. Lan C, Lai JS, Wong MK, Yu ML. Cardiorespiratory function, flexibility, and body composition among geriatric Tai Chi Chuan practitioners. *Arch Phys Med Rehabil.* 1996;77(6):612-6. [PubMed: 8831482].
35. Chen CY, Bonham AC. Postexercise hypotension: central mechanisms. *Exerc Sport Sci Rev.* 2010;38(3):122-7. doi: [10.1097/JES.0b013e318e372b5](https://doi.org/10.1097/JES.0b013e318e372b5). [PubMed: 20577060].
36. Halliwill JR. Mechanisms and clinical implications of post-exercise hypotension in humans. *Exerc Sport Sci Rev.* 2001;29(2):65-70. [PubMed: 11337825].
37. Rezk CC, Marrache RC, Tinucci T, Mion DJ, Forjaz CL. Post-resistance exercise hypotension, hemodynamics, and heart rate variability: in-

- fluence of exercise intensity. *Eur J Appl Physiol*. 2006;**98**(1):105-12. doi: [10.1007/s00421-006-0257-y](https://doi.org/10.1007/s00421-006-0257-y). [PubMed: [16896732](https://pubmed.ncbi.nlm.nih.gov/16896732/)].
38. Marcus BH, Williams DM, Dubbert PM, Sallis JF, King AC, Yancey AK, et al. Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. *Circulation*. 2006;**114**(24):2739-52. doi: [10.1161/CIRCULATIONAHA.106.179683](https://doi.org/10.1161/CIRCULATIONAHA.106.179683). [PubMed: [17145995](https://pubmed.ncbi.nlm.nih.gov/17145995/)].