JETR

JOURNAL OF
EXERCISE THERAPY
AND REHABILITATION

Journal of Exercise Therapy and Rehabilitation. 2019;6(1):25-31

ORIGINAL ARTICLE

Is 2-week calisthenics high-intensity interval training enough to change aerobic and anaerobic capacity?

M Abdullatif ALSAIRAWAN[1], Barış GÜRPINAR[2], Nursen İLÇİN[2]

Purpose: The purpose of the study is to examine the effects of high-intensity interval calisthenics training (HIIT) performed over two weeks on aerobic and anaerobic capacity.

Methods: Twenty-three college age inactive (The International Physical Activity Questionnaire (IPAQ) <600 metabolic equivalents (MET) volunteers were randomly divided into two groups. HIIT (N=12) group performed 6 sessions of calisthenics HIIT program over two weeks, the control group was asked not to change their activity level. Aerobic capacity was measured with 20-m Multistage Shuttle Run Test and anaerobic capacity was tested with Wingate anaerobic test, also peripheral muscle strength was assessed by back and leg dynamometer, initially and two weeks later for both groups.

Results: Aerobic capacity increased from 34.44±8.88 ml/kg/min to 38.52±52 ml/kg/min ($p<0.05$) in HIIT group. Leg and back muscle strength significantly improved in the same group ($p<0.05$). Although peripheral isometric muscle strength increased anaerobic capacity did not change ($p>0.05$). There was no change in any of the outcome measures of the control group ($p>0.05$).

Conclusion: This study showed that two weeks calisthenics HIIT is safe and effective in improving aerobic capacity and periphery muscle strength in sedentary young individuals.

Keywords: High-intensity interval training, Exercise, Cardiorespiratory fitness.

İki haftalık kalistenik yüksek şiddetli aralıklı egzersiz aerobik ve anaerobik kapasiteyi artırmaya yeterli midir?

Amaç: Bu çalışmanın amacı, iki haftalık kalistenik yüksek şiddetli aralıklı egzersizin (YŞAE) aerobik ve anaerobik kapasite üzerindeki etkilerini incelemektir.

Yöntem: 23 gönüllü inaktif (Uluslararası Fiziksel Aktivite Anketi-Kısa Form (IPAQ) <600 Metabolik Eşdeğer (MET)) üniversite öğrencisi randomize olarak iki gruba ayrıldılar. YŞAE (N=12) grubu iki hafta içerisinde 6 seans kalistenik YŞAE yaparken kontrol grubuna aktivite seviyelerini değiştirmemeleri önerildi. İki haftanın başında ve sonunda, aerobik kapasite ölçümü için 20 m mekik koşu testi ve anaerobik kapasite için Wingate anaerobik test, periferik kas gücü içinse bacak ve sırt dinamometresi ölçümleri yapıldı.

Bulgular: YŞAE grubunda iki hafta sonunda aerobik kapasite 34,44±8,88 ml/kg/dk seviyesinden 38,52±52.00 ml/kg/dk seviyesine yükseldi ($p<0,05$). Aynı zamanda bacak ve sırt kas kuvvetinde anlamlı bir artış görüldü ($p<0,05$). İzometrik kas kuvvetinde artış görülmesine rağmen anaerobik kapasitede değişiklik olmadı ($p>0,05$). Kontrol grubunun herhangi bir çıktısında değişiklik ölçülmedi ($p>0,05$).

Sonuç: Bu çalışma iki haftalık kalistenik YŞAE genç inaktif bireylerde aerobik kapasite ve periferik kas kuvvetini arttırmada etkili ve güvenli olduğunu ortaya koymaktadır.

Anahtar kelimeler: Yüksek şiddetli aralıklı egzersiz, Egzersiz, Kardiyo respuratuvar uygunluk.

Alsairawan MA, Gürpınar B, İlçin N. Is 2-week calisthenics high intensity interval training enough to change aerobic and anaerobic capacity? J Exerc Ther Rehabil. 2019;6(1):25-31. *İki haftalık kalistenik yüksek şiddetli aralıklı egzersiz aerobik ve anaerobik kapasiteyi artırmaya yeterli midir?*

1: Dokuz Eylul University, Health Science Institute, Izmir, Turkey.
2: Dokuz Eylul University, School of Physical Therapy and Rehabilitation, Izmir, Turkey.
Corresponding author: Barış Gürpınar: eski-baris@hotmail.com
ORCID ID: 0000-0003-3886-4819
Received: February 8, 2018. Accepted: February 5, 2019.

Recent studies revealed an inverse relation between mortality and activity intensity, moderate to vigorous activity associated with mortality risk reduction.[1,2] Authors also recommended that higher level activities should be encouraged in clinical guidelines and public health.[1] High-intensity exercises are difficult to maintain as the intensity matches almost to the maximum load. Therefore bouts of intensive exercises followed by various recovery times were been introduced instead of continuous training, mainly called High-Intensity Interval Training (HIIT). Recent evidence suggested that HIIT is effective as much as continuous training in reducing cardiovascular risks and improving muscle and cardiac metabolic functions.[3,4] HIIT increases resting muscle glycogen, muscle endurance capacity and fat oxidation.[4,5] Additionally, HIIT exercises are found more enjoyable in both healthy and unhealthy population.[6]

HIIT has been using for athletes almost a century now, and in the last decade an increasing number of papers pointed out safety and affectivity in patients with different diagnosis.[7,8] Although a growing body of research shows that HIIT is an effective, safe, time efficient and enjoyable type exercises, there is no consensus on training protocol and/or exercise principles. Exercise modality is one of the nine variables which manipulate the effects of the physiological response of HIIT.[3] Many of the studies used bicycle ergometer or treadmill running for HIIT.[7,9,10] Equipment is easy to adjust loading yet difficult to find or scant in any setting. Calisthenics HIIT exercises could be the solution as they have similar acute responses with bicycle ergometer.[5] Additionally, calisthenics exercises would increase muscle volume which could lead metabolic and physiological changes which also may alter the adaptations to exercise.[9,11,12] There are few studies investigated calisthenics exercises in HIIT form their findings showed that calisthenics HIIT is an effective and safe in physically active individuals.[5,13,14]

Only burpee exercise was chosen for the study to avoid the effects of exercises interfere with each other. Burpee is one of the widely used calisthenics exercises which involve both upper and lower extremities as well as trunk control. Also, burpee requires a high level of acute metabolic demand yet relatively easy to understand and perform.[5,13]

It is also important to understand the HIIT physiological short-term aerobic and anaerobic response to design effective exercise prescriptions. Determining time demanding changes of exercise response is critical in manipulating HIIT variables. Short term HIIT has been using in few studies to identify time-efficient strategies.[9,15,16] Two weeks HIIT programme was found as effective as continuous aerobic exercise, in increasing muscle oxidative capacity, although had 90% lower exercise volume.[17] These studies mostly focused on active and/or trained individuals and mainly used running and cycling based exercises. To our knowledge, related literature is a lack of short calisthenics HIIT physiological response in inactive individuals.

The aim of this study was to investigate the cardiovascular, functional capacity and muscle strength responds of calisthenics HIIT in sedentary individuals. The knowledge obtained from the study helps to inform the development and practical application of calisthenics HIIT sessions for sedentary individuals.

METHODS

The number of participants was calculated based on 0.05 probability level, 1.16 effect size[5] and %95 statistical power level by GPower Software (ver. 3.0.10) and the calculation revealed that at least 11 participants had to be included in each group.

This study was carried out on 23 healthy university students (Nine male and 14 female) volunteered to take part in this study. Students who obtained a lower score than 600 MET in International Physical Activity Questionnaire (IPAQ) were selected.[18] Before applying the exercises, the subjects were divided randomly into two groups. Twelve subjects (5 male and 7 female) were assigned to a training group and they have received six sessions of short-term high-intensity interval training for two weeks. The other eleven subjects (2 male and 9 female), who served as a control group, were asked to continue their daily activities normally without taking any exercise program also for two weeks. The study protocol was

approved by the Ethical Committee of Dokuz Eylül University in Izmir, Turkey (Approval No. 2016/04-28). Also, the subjects were informed about the study procedures and the associated risks and all subjects provided written informed consent. 18-24 years of age volunteers were included to the study where participants who have; juvenile/adult cardiovascular or musculoskeletal disorder, the habit of regular exercising at least in previous three months, contraindication to exercise were excluded. Participants also willing to leave or developed acute health problems discarded from the study.

Before taking any part in the study, all subjects were given a presentation with a brief introduction about all of the tests. Then, they performed familiarization trials to become oriented with all testing steps and equipment.

Participants performed 20-m Multistage Shuttle Run Test (SRT), a standardized procedure to determine the aerobic capacity (VO_2max). The participant ran between two points, which are set to be 20 m apart while keeping pace with a recorded rhythm. The rhythm is set to a specific sequence, which increases every minute. Participants were instructed to cope with the rhythm for as long as possible. The test was ended when the participant failed to reach the appropriate point in the allotted time twice or could no longer maintain the pace. The number of completed laps were counted and employed to calculate VO_2 max.[19]

Anaerobic capacity was tested with Wingate anaerobic test with cycle ergometer (Monark, 894E, Stockholm, Sweden) the height of the seat was adjusted for each participant. This test requires maximal pedalling for 30 sec against a frictional resistance, which based upon body weight (7.5% of subject's weight). The Wingate Anaerobic test provides three indicators: the peak power, the mean power, and fatigue index.[20]

In order to estimate the leg strength, Takei (Tokyo, Japan) dynamometer was used as follow. Individuals instructed to stand on the foot-plate of the dynamometer with the scapulae and buttocks positioned flat against a wall. Approximately 15 cm is the distance between the back of the foot and the wall. In addition to that, a pendulum goniometer is placed 10 cm above the patella and it was zeroed. Individuals flexed their legs, sliding down the wall until the leg extension angel equals to (2.36 rad). Individuals then reached down with the elbow fully extended. The pull-bar of the dynamometer was placed in their hands and the chain length was adjusted appropriately. Individuals were instructed to extend their legs with maximal effort, pulling the bar simultaneously and the highest score from three tries was recorded.[21]

The back strength was also measured with the assessment of Takei dynamometer in the same way as for the measurement of leg strength. The individuals put their legs on the dynamometer foot-plate with the knees and the arms are kept stretched and the back was flexed at the hip. Then the individuals slightly leaning forward, pulling up the dynamometer bar vertically up to the maximum position. This traction was repeated three times and the best value was recorded.[21]

After initial evaluation participants were randomly assigned to either the control or intervention group. Control group was asked to continue their normal life without doing any physical training, to ensure that no change has occurred in the physical activities of the participants an interview was carried out once in a week.

The intervention group was given training twice in a week for a period of two weeks with 48 to 72 rest hours between sessions. The designed exercise program consists of; 5 min of warming up exercises. In 15-minute main exercise consist of burpees (Figure 1) participants encourage performing as many as burpees in 30 seconds, 85% of the maximum intensity should be achieved within the 30 secs. The maximum intensity is calculated according to Karvonen Formula[22] by using the subject's heart rate which was monitored during the exercises by a heart rate monitor (Onrhythm 310 Geonaute). Following 3 minutes the subject is actively resting by jogging in place for 3 minutes until reaching and maintaining the 60% of the maximum intensity. This 3.5-minutes loop was repeated for 4 four times. The training program then ends with 5 min of cooling down exercises.

Two weeks after the initial test, post-training tests identical to previously described pre-training tests were conducted for each participant.

Statistical analysis

SPSS for Windows version 20.0 was used for statistical analysis. Descriptive data were identified with frequency values and percentiles. Data generated from calculations were given with mean and standard deviations. Mann Whitney U test was used in comparing two different groups where Wilcoxon signed rank test was used in comparing initial and final measurements. The overall statistical significance was accepted as $p<0.05$.

RESULTS

23 inactive participants with the mean age 22.08±0.99 years and average BMI 22.80±2.74 kg/m^2 were included in the study. The participants' characteristics are shown in Table 1. There were no significant baseline differences between groups ($p>0.05$).

After two weeks HIIT MaxVO_2, the distance of SRT and leg and back muscle strength increase significantly where heart rate after SRT decreased statistically significant ($p>0.05$). There was no change demonstrated in the control group within two weeks in any of the measurements. MaxVO_2, the distance of SRT and leg and back muscle strength and heart rate after SRT were statistically different between groups after two weeks (Table 2).

Participants completed two weeks of HIIT burpee exercises in 85% of their maximum HR with no harms or unintended effects reported.

DISCUSSION

This study investigates aerobic and anaerobic responses to two weeks calisthenics HIIT exercises in healthy and inactive individuals. To our knowledge, this is the first study investigating calisthenics HIIT exercises in healthy and inactive individuals. The results of the study showed that calisthenics HIIT is safe and effective, even in two weeks, in increasing aerobic capacity and peripheral muscle strength but not anaerobic capacity.

HIIT has been mainly used for athletes, however, there has been a growing body of evidence pointed out that inactive population and even people with certain health problems benefit this type of exercise.[7,8,23] The results of our study were consistent to relevant literature. Six sessions of calisthenics HIIT improved cardiovascular endurance and muscle strength of inactive college-aged individuals with no adverse effect.

It is well documented that HIIT is an effective method in improving aerobic capacity. However, it is not clear if it is superior to continuous aerobic exercise. 18 weeks of HIIT programme was found better in increasing VO_2 max than continuous moderate exercise.[24] While 6 weeks of HIIT programme and continuous aerobic exercise increased VO_2 max at the same extend.[25] HIIT studies modified different aspects of HIIT such as loading or recovery time and intensity, to understand the physiology behind this type of exercise, however, few of them modified the exercise modality.[26] Running and cycling exercises dominates the literature. A modest number of studies used swimming,[27,28] throwing[29] or calisthenics exercises.[5,13] Gist et al used burpee exercises for HIIT sessions to compare with continuous cycling exercises and investigated acute peak cardiorespiratory responses during each exercise modality.[5] The results of the study pointed out that during, HIIT burpee exercises, aerobic capacity increased as much as continuous exercises. The results of the study correlate our findings. Although burpee is not regular aerobic exercise modifying it into a HIIT session increases cardiovascular capacity.

We used burpee exercise for intensive bouts of training which involves push-ups followed by powerful jumps. Burpee needs an explosive power of upper and lower extremities; therefore, it is reasonable to expect enhanced mean or peak power outcome following burpee HIIT. Moreover, as HIIT contains short bouts of intense maximal even supramaximal exercise which is linked to the Wingate test protocol used to measure anaerobic capacity. However, the evidence on the effects of HIIT on anaerobic capacity is unclear[30] our results revealed no difference between the initial and last measurement of anaerobic capacity this may be lack of jumping power generated by participants. Studies show HIIT exercises increased anaerobic capacity however these studies applied cycling as the intervention, therefore, specificity of the training could affect

the results.[12,31]

Although numerous studies are investigating HIIT, there is no consensus on training protocol. It is well known that 6 sessions of HIIT undertaken over 2 weeks is effective to improve cardiorespiratory fitness, insulin sensitivity, and muscle oxidative potential.[15,16] Our study showed that 2 weeks of HIIT well enough to increase aerobic capacity and muscle strength with 2 weeks calisthenics HIIT. Yet, anaerobic capacity did not change after 6 sessions of calisthenics HIIT unlike other studies.[11,12]

Limitations

This study expressed short-term HIIT effects on aerobic capacity and peripheral muscle strength yet the study did not include follow-up, therefore, it is not clear how long

Figure 1. Burpee exercise begins with squat position by flexing the knees and hips and places the hands on the ground in front of the feet. Plank position is taken by kicking the feet back and returns to the squat by tucking knees in. Extend the knees/hips and leap up as high as possible from the squat position with the arms extended overhead.

Table 1. Characteristics of the participants.

	HIIT Group N=12 X±SD	Control Group N=12 X±SD	
Age (year)	22.08±0.99	21.72±1.67	*
Height (cm)	170.00±10.65	165.72±9.28	*
Body weight (kg)	65.71±8.96	62.40±16.70	*
Body mass index (kg/m^2)	22.80±2.74	22.45±4.10	*
Gender (Female/Male)	5/7	9/2	*

* p<0.05. HIIT: High-Intensity Interval Training.

Table 2. Outcome measures at baseline and 2 week for HIIT and Control groups.

	HIIT Group		Control Group	
	Baseline	2 weeks	Baseline	2 weeks
	X±SD	X±SD	X±SD	X±SD
Max VO_2 (ml/kg/min)	34.44±8.88	38.52±52.00*¥	26.80±4.12	26.12±2.91
SRT distance (m)	940.00±498.57	1176.66±568.75*¥	505.45±211.86	514.54±238.34
Hart rate after SRT (beat/min)	174.91±34.27	169.83±30.93*¥	155.72±30.04	168.45±23.69
Wingate test - Peak power (Watts)	9.30±1.79	9.72±2.17	7.21±1.77	7.53±1.69
Muscle power (kg)				
Leg	85.66±27.58	94.54±30.00*¥	53.31±15.81	53.81±16.34
Back	83.95±26.18	98.70±25.83*¥	67.13±25.60	66.36±23.70

* p<0.05 Between baseline and 2 weeks in HIIT Group. ¥ p<0.05 between HIIT and Control groups. SRT: Shuttle Run Test. HIIT: High-Intensity Interval Training.

this effect lasted. Burpee exercise was chosen as a calisthenics exercise as it involves almost all parts of body however upper limb muscle strength did not include. It would be interesting to have follow-up results and studies which compares different calisthenics HIIT exercises protocols' results.

Conclusion

In summary, the findings of the present study demonstrated that 2-week HIIT increase aerobic capacity and peripheral muscle strength but not anaerobic capacity. Another finding of this study was 2-week calisthenics is a safe intervention in college-age inactive people. Although HIIT has an extensive literature most of the studies modify the timing and /or intensity of loading and recovery period. Calisthenics HIIT is rather a new application for the current literature so other studies are needed on calisthenics HIIT.

Acknowledgement: *The authors wish to thank MSc PE Egemen Mancı for his precise work for supporting the present work.*

Conflict of interest: *None.*

Funding: *None.*

REFERENCES

1. Gebel K, Ding D, Chey T, et al. Effect of moderate to vigorous physical activity on all-cause mortality in middle-aged and older Australians. JAMA Intern Med. 2015;175:970-977.
2. Arem H, Moore SC, Patel A, et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. JAMA Intern Med. 2015;175:959-967.
3. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Sports Med. 2013;43:313-338.
4. Tsuchiya Y, Ando D, Goto K, et al. High-intensity exercise causes greater irisin response compared with low-intensity exercise under similar energy consumption. Tohoku J Exp Med. 2014;233:135-140.
5. Gist NH, Freese EC, Cureton KJ. Comparison of responses to two high-intensity intermittent exercise protocols. J Strength Cond Res. 2014;28:3033-3040.
6. Bartlett JD, Close GL, MacLaren DP, et al. High-intensity interval running is perceived to be more enjoyable than moderate-intensity continuous exercise: implications for exercise adherence. J Sprots Sci. 2011;29:547-553.
7. Meyer P, Gayda M, Juneau M, et al. High-intensity aerobic interval exercise in chronic heart failure. Curr Heart Fail Rep. 2013;10:130-138.
8. Boyne P, Dunning K, Carl D, et al. High-intensity interval training in stroke rehabilitation. Top Stroke Rehabil. 2013;20:317-330.
9. Ahmadizad S, Avansar AS, Ebrahim K, et al. The effects of short-term high-intensity interval training vs. moderate-intensity continuous training on plasma levels of nesfatin-1 and inflammatory markers. Horm Mol Biol Clin

Investig. 2015;21:165-173.
10. Peake JM, Tan SJ, Markworth JF, et al. Metabolic and hormonal responses to isoenergetic high-intensity interval exercise and continuous moderate-intensity exercise. Am J Physiol Endocrinol Metab. 2014;307:E539-E552.
11. Awobajo FO, Olawale OA, Bassey S. Changes in blood glucose, lipid profile and antioxidant activities in trained and untrained adult male subjects during programmed exercise on the treadmill. Nig Q J Hosp Med. 2013;23:117-124.
12. Astorino TA, Allen RP, Roberson DW, et al. Effect of high-intensity interval training on cardiovascular function, VO2max, and muscular force. J Strength Cond Res. 2012;26:138-145.
13. Gist NH, Freese EC, Ryan TE, et al. Effects of Low-Volume, High-Intensity Whole-Body Calisthenics on Army ROTC Cadets. Mil Med. 2015;180:492-498.
14. McRae G, Payne A, Zelt JG, et al. Extremely low volume, whole-body aerobic-resistance training improves aerobic fitness and muscular endurance in females. Appl Physiol Nutr Metab. 2012;37:1124-1131.
15. Burgomaster KA, Heigenhauser GJ, Gibala MJ. Effect of short-term sprint interval training on human skeletal muscle carbohydrate metabolism during exercise and time-trial performance. J Appl Physiol (1985). 2006;100:2041-2047.
16. Esfandiari S, Sasson Z, Goodman JM. Short-term high-intensity interval and continuous moderate-intensity training improve maximal aerobic power and diastolic filling during exercise. Eur J Appl Physiol. 2014;114:331-343.
17. Gibala MJ, Little JP, van Essen M, et al. Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance. J Physiol. 2006;575(Pt 3):901-911.
18. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35:1381-1395.
19. Léger LA, Mercier D, Gadoury C, et al. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci. 1988;6:93-101.
20. Inbar O, Bar-Or O, Skinner JS. The Wingate anaerobic test: John Wiley & Sons; 1996.
21. Coldwells A, Atkinson G, Reilly T. Sources of variation in back and leg dynamometry. Ergonomics. 1994;37:79-86.
22. Robergs RA, Landwehr R. The surprising history of the "HRmax=220-age" equation. Journal of Exercise Physiology Online. 2002;5:1-10.
23. Garcia-Hermoso A, Cerrillo-Urbina AJ, Herrera-Valenzuela T, et al. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis. Obes Rev. 2016;17:531-540.
24. Tjønna AE, Lee SJ, Rognmo Ø, et al. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome. Circulation. 2008;118:346-354.
25. Burgomaster KA, Howarth KR, Phillips SM, et al. Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans. J Physiol. 2008;586:151-160.
26. Gist NH, Fedewa MV, Dishman RK, et al. Sprint interval training effects on aerobic capacity: a systematic review and meta-analysis. Sports Med. 2014;44:269-279.
27. Motta VF, Aguila MB, Mandarim-De-Lacerda CA. High-intensity interval training (swimming) significantly improves the adverse metabolism and comorbidities in diet-induced obese mice. J Sports Med Phys Fitness. 2016;56:655-563.
28. Faude O, Meyer T, Scharhag J, et al. Volume vs. intensity in the training of competitive swimmers. Int J Sports Med. 2008;29:906-112.
29. Mokha M, Maddigan ME, Behm DG, et al. High-intensity interval training for improvement of overhand throwing velocity. Int J Athl Ther Trai. 2014;19:36-40.
30. Weston M, Taylor KL, Batterham AM, et al. Effects of low-volume high-intensity interval training (HIT) on fitness in adults: a meta-analysis of controlled and non-controlled trials. Sports Med. 2014;44:1005-1017.
31. Souza-Silva AA, Moreira E, de Melo-Marins D, et al. High intensity interval training in the heat enhances exercise-induced lipid peroxidation, but prevents protein oxidation in physically active men. Temperature (Austin, Tex). 2016;3:167-175.