Effect of High Intensity Interval Training with Blood Restriction on Anaerobic Performance

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Abstract
Limiting venous blood flow restriction is a new approach of training aims to improving high level of performance among athletes, which has shown prominent results at muscle hypotrophy and strength. KAATSU1 is a training system including pressure belt imposed on the proximal part of the upper and lower bodies. The present study aims to investigate the effect of HIIT Kaatsu trainings on anaerobic performance among young athletes. The present quasi experimental research was conducted through a pre-test and post-test and three groups including KAATSU intensive interval exercises (n=11), intense interval exercise (n=9) and a control group (n=10). The exercises included running distances of 20 and 40 meters. In the beginning of the protocol most of the exercises was in short distances and as the sessions proceeded, the number of the sets and repetitions increased and it reached to its highest intensity in the last session. During the exercise protocol, intensity of training was considered to be the highest running speed and based on their abilities each individual tried to run as fast as possible. The exercise load was defined based on repetitions and the sets. In the 20 meters distances, the participants took a ten second rest after each repetition and a one minute rest after each set and in 40 meters distances; Subjects took a 20 second rest after each repetition and 2 minute rest between sets. The control group did not performed any of the mentioned exercises. Moreover, before and after four weeks of training the individuals were given RAST and Anaerobic Biking Wingate Test. Statistical result has been shown, there is a significant change between the maximum anaerobic power in Wingate biking test after four weeks within KAATSU intensive (P< 0.05) and intensive interval (P< 0.05) groups, but no significant change was detected in the control group (P> 0.05). The statistical analysis of this research has been shown that there is of current investigation indicated that compared to intensive interval exercise alone, attending the KAATSU intensive exercises is more effective on the highest anaerobic power (Wingate bike) and the lowest as well as the average of anaerobic power.

Keywords: Intensive Anaerobic Exercises, Blood Flow Restriction, Anaerobic Power, Fatigue Index

1 Vascular Occlusion Moderation Training
1. Introduction:

Anaerobic power capacity and acquiring it in high levels is a factor of success for elite athletes in many sport fields specifically at sprint and power performances. Scientists in recent years have made much effort working on various methods of improving anaerobic power through exercise and developing difference exercise protocols. For example, different types of HIIT\(^2\) exercises, different interval exercises and complement exercises such as strength, power and speed which is done by a weight as well as combination exercise. Meanwhile, various exercises systems have been developed for this issue. Among the systems developed regarding this issue is the KAATSU system which is influential in anaerobic power and other capacities.

The limitation of venous blood circulation is a rather new method of training which has yielded notable results regarding muscle hypotrophy and resistance achievements. KAATSU is a training system including pressure belt imposed on the proximal part of the upper and lower organs[1]. KAATSU has been developed by Dr. Yushiai Sato in Japan during 40 years and its literal meaning is exercise with added pressure. The purpose of the added pressure is to limit the blood flow to the working muscles which causes the accumulation of blood in organs’ capillaries. Blood accumulation in capillaries decreases the amount of the blood going to heart and as a result the arterial blood flow will be decreased. When the blood flow to the muscles diminishes, the amount of Oxygen and nutrient especially Glucose will be reduced to a large extent which is the factor of the muscles’ adaptation with low amount of oxygen. The hypoxia caused by limiting the blood flow increases the growth hormone release, Norepinephrine, IFG-1[2] and other hormones related to Hypertrophoy adaptation and power boost. Bitchel & Earl, 2000, American college of sports medicine, 2002 came to the conclusion that the resistance of 65% or higher is required for stimulus in order to reach the strength and the hypertrophy. Using KAATSU bands and limiting the blood flow shows that even in low intensities, 20 % of a maximum repetition along with capillary restriction (limitation) can bring about the increase in the muscles’ mass (size)[3].

Intensive interval exercise is among the protocols often carried out by athletes for the great help it can give them in the process of preparation for enjoying optimal performance. It is often used as an exercise method influential in the improvement of preparation level in a short period of time.

Oliviera et al., in a four week study, investigated and compared the effect of four different protocols of interval exercise on the aerobic preparedness and muscle’s power of 37 individuals who were assigned to four groups of low intensity interval with or without BFR and high intensity interval and the combination of HIT-BFR. The results indicated that the OBLA was improved in all four groups but the Vo2MAX and PMAX were improved just in BFR, HIT, HIT-BFR groups and muscles’ power achievement was made only after BFR exercises[4].

Kono et al., conducted a four week research study regarding the short and long

\(^2\) - High Intensity Interval Training
term effect of sprint interval exercises with post-exercise on limiting the blood flow restriction including control and BFR groups. The Vo2MAX after BFR increased as much as 4.5% but no change was made in the control group. In the second study of phosphorylation, after 3 hours of BFR exercise the P38MAPK increased[5]. Yasuda et al., studied the effect of low intensity of resistance exercise with the elasticity of combination band along with limiting the blood flow on muscle activation. There were 9 participants who carried out the exercises for a period of one week. Muscle activation under BFR exercise in both Flexion and Extension phases of arm increased 46% and 49% respectively but it was not the case regarding the control group. Compared to that of the control group, Lactate density of blood in BFR was higher which is highly related to the increase of iEMG in biceps brachii and triceps brachii[6]. Lorsen et al., gave a bike riding group a two week intensive interval exercise each week including two sessions. The exercise protocol in this study contained twenty sets of immobile biking exercise in maximum output power each set lasting for sixty seconds along with 120 second recovery. As a result of this research the maximum exit power was significantly raised and the study suggested that intensive interval exercise can boost the maximum exit power during just four exercise sessions[7]. In another study, the influence of intensive interval exercise on active males during six weeks was investigated. Each week included six sets of 90 seconds pedaling in 80 percent of maximum oxygen consumption along with 180 seconds of active rest for three sessions a week. The result of this study indicated a significant increase in the maximum oxygen consumption, average and maximum anaerobic power[8]. The view that through shortening the time period of reaching the anaerobic power and in equal time period, we can acquire higher anaerobic power compared to other methods, gave us the motivation and the new idea to employ the KAATSU interval method. We are going to acquire higher amount of anaerobic power in a shorter time therefore we can achieve this goal through employing the mentioned method. Although there are various ways of boosting the anaerobic power, being able to get to our purpose faster and without using supplements is what matters. If HIT exercise is done, during four weeks the anaerobic power can be boosted and this has already been substantiated[8, 9]. Athletes always try to improve their efficiency by using less amount of energy and employing their utmost performance. Therefore, doing exercise higher than Lactate threshold along with the notable amount of the acid produced for the athletes who are in need of making maximum effort uninterruptedly, brings a lot of advantages. Now, we are going to see the effect of KAATSU interval on these indexes (factors). Anaerobic indexes of power for athletes must be improved in the best way possible. Increasing advancement of championship (professional) sport and the importance of the factors needed for its optimal performance has provided the motivation required to employ the scientific and new methods of reaching to these indexes. Improving body’s abilities must receive considerable attention during exercises. KAATSU exercises have been shown to be influential in anaerobic exercises but there seems to be no studies conducted regarding similar HIIT exercises. No this question arises that whether it is possible to reach the anaerobic power in a shorter time or if we can boost the anaerobic power in an equal time span. But regarding the necessity of conducting this study it can be said that: KAATSU has shown to be effective in anaerobic and Metabolite accumulation process which is related to the fatigue index. It has also been studied regarding interval in swimming. On the basis that the concept of KAATSU itself
implies that limiting (obstruction) of blood flow in low pressure and high repetition is similar to the weight with low intensity and high repetition. It is also true about HIIT or interval exercises because not 100% of the power is put on the muscle. In Practice we can see that in interval exercises not 100% of the power is used and we just use the burden of the weight. Therefore, we can simulate the interval exercises to see the effect of KAATSU interval exercises. There have been few studies regarding the effect of KAATSU interval system on the increase of anaerobic power of athletes. The previous studies suggested that using KAATSU can boost the employment of fast twitch fibers in exercises. Due to the decrease in aerobic enzymes, employing KAATSU in interval exercises, we can theoretically employ higher numbers of fast twitch fibers. Researches have indicated that the increase in the power and hypertrophy can both improve the RMI and be a base of the anaerobic activities, power and hypertrophy. When somebody has both hypertrophy and power, they can boost the anaerobic power. Therefore, the present study aims to investigate the effect of HIIT Kaatsu trainings on young athletes’ anaerobic performance.

2. Material and Methodologies
1-2 Population
Thirty young male active student recruited for participating in this study. They were randomly divided in three groups; KAATSU intensive interval exercises (n=11), intense interval exercise (n=9) and a control group (n=10). Consent form were completed before start the research and familiar session were performed before pre-tests.

2-2 Data Collection Methodology
To measure the participants’ height, Measuring Rod Rulers was used and the participants were asked to hold their head and body in appropriate position and avoid wearing shoes or any other piece of clothing which may make the measurement inaccurate. After that, using digital balance, they were weighed by the precision of 0/1 kilogram.

1-2-2 Cuff Pressure
Incrementally cuff pressure were increased from first to end season of exercise protocols. In the first session of the exercise for the purpose of body adaptation and avoiding any injuries, the imposed pressure was 14 mmHG and to reach the aimed pressure, from the second session the pressure was increased to 18 mmHG.

2-2-1 Exercise Protocol
The exercise protocol included distances of 20 and 40 meters. Researcher used low level of intensity at beginning and increased intensity while volume of exercise was decreased by the last session. The exercise load in this exercise schedule was determined based on the repetitions and sets. Individuals in distances of 20 meters took a 10 second rest after each repetition and a one minute rest between sets. In 40 meter distances, subjects rested 20 seconds after each repetition and two minutes rest performed between sets.

3-2 Anaerobic Test Protocols
Wingate anaerobic test was used for assessing the anaerobic capacity and the anaerobic power. The maximum effort of 30 seconds on cycle Ergometer was applied to determination of anaerobic performance. Maximum and minimum power were recorded by the monark software and fatigue indexed was calculated by taking
the account peak and minimum anaerobic power and protocol duration.

2-4 RAST Test
Two cones were put at a distance of 35 meters from each other. The subjects were warms up for 5 minutes and then they stand behind the cone (A) in stand-by mode and upon hearing the word “go” by the examiner, the participant run as fast as possible towards the cone (B). The running time between the two cones was recorded by the examiner and right after crossing the cone (B) and then 10 second resting time begins. The participant repeats it for five more times and always performed 10 seconds rest between. Using the following formulas, the power for each stage and then the minimum, the maximum and the average power is calculated.

\[ \text{Power} = \text{Weight} \times \text{Distance}^2 \div \text{Time}^3 \]

\[ \text{Fatigue index} = \frac{\text{(maximum power} - \text{minimum power)}}{\text{total time for the 6 sprints}} \]

2-5 statistical analysis
Kolmogorov-Smirnov was applied for determination of normality among the groups. ANOVA one way was applied to determination of between groups’ differences and Paired T-test was used to determination of variables changes within the groups from pre to post test. SPSS software was employed to analyze the data.

3. Research Findings
Statistical result has been shown, there is a significant change between the maximum anaerobic power in Wingate biking test after four weeks within KAATSU intensive interval (P≤ 0.05) and intensive interval (P≤ 0.05) groups, but no significant change was detected in the control group (P> 0.05). Analysis of variance has been shown significant difference in maximum anaerobic power among groups (P≤ 0.05). (In compare with control group). By the way there is not any significant differences between intensive interval and KAATSU intensive interval groups.

Paired t-test has been shown, there is significant change in peak anaerobic power from pre to post test in RAST anaerobic test in control and HIIT groups. By the way nothing chanced in KAATSU group (P≤ 0.05). In addition, significant changes was detected in KAATSU intensive interval (P≤ 0.05) group regarding fatigue index in the RAST test after four weeks. Also has been shown there is not significant changes in control (P> 0.05), and intensive interval (P> 0.05) groups from pre to post test.

Table 1: ANOVA one way for Peak Anaerobic Test (Wingate)

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
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<tbody>
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<td>Wingate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Between Groups</td>
<td>54597.302</td>
<td>2</td>
<td>27298.651</td>
<td>11.555</td>
<td>.000</td>
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<tr>
<td>Within Groups</td>
<td>63785.898</td>
<td>27</td>
<td>2362.441</td>
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<td></td>
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<tr>
<td>Total</td>
<td>118383.200</td>
<td>29</td>
<td></td>
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Table 2: Paired Samples Test (Wingate)

<table>
<thead>
<tr>
<th>group</th>
<th>Paired Differences</th>
<th>Std. Error</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation Mean</td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTROL</td>
<td>7.700</td>
<td>34.538</td>
<td>10.921</td>
<td>-17.007</td>
<td>32.407</td>
<td>.704</td>
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<tr>
<td>intensive interval exercises</td>
<td>-64.888</td>
<td>41.302</td>
<td>13.767</td>
<td>-96.636</td>
<td>-33.141</td>
<td>-4.713</td>
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<td>KAATSU intensive interval exercises</td>
<td>-91.909</td>
<td>62.771</td>
<td>18.926</td>
<td>-134.079</td>
<td>-49.738</td>
<td>-4.856</td>
</tr>
</tbody>
</table>

Table 3: Paired T-test for Peak Anaerobic Test (Wingate)

<table>
<thead>
<tr>
<th>mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>control</td>
<td>intensive interval exercises</td>
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<tr>
<td>Pre Test</td>
<td>794.7</td>
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<td>Post Test</td>
<td>787</td>
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</table>

Table 4: ANOVA one way for Fatigue Index (RAST)

<table>
<thead>
<tr>
<th>FI (RAST)</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>107.464</td>
<td>2</td>
<td>53.732</td>
<td>1.828</td>
<td>.18</td>
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<tr>
<td>Within Groups</td>
<td>793.568</td>
<td>2</td>
<td>29.391</td>
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<td></td>
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<tr>
<td>Total</td>
<td>901.033</td>
<td>2</td>
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**Discussion and conclusion**

In the present study, there was a significant change between KAATSU intensive interval and intensive interval regarding the maximum anaerobic power in Wingate biking test after 4 weeks but there was no change in the control group. It is worth mentioning that the increase in KAATSU intensive interval (11.11%) was higher than that of intensive interval (9.45%). Furthermore, there was a significant difference in the post-tests of intensive interval and KAATSU intensive interval but it was not the case about the KAATSU intensive interval and intensive interval. The increase in the experimental groups’ power output was in line with most of the studies conducted so far[10-15].

In the present study, there was a significant change regarding the maximum and the average anaerobic power of the Rest test after 4 weeks in the KAATSU intensive interval and the intensive interval but there was no such change in the control group. The increase in both groups of KAATSU intensive interval 74.18% and intensive interval 75.78 % was almost the same. There was also a significant change regarding the minimum anaerobic power in the Rest test of KAATSU intensive interval and intensive interval after 4 weeks. But there was no such change in the control group. The increase in the KAATSU intensive interval 114.9% was higher than that of the intensive interval group 96.45%. There was also a significant change regarding the average anaerobic power in the Rest test of KAATSU intensive interval, intensive interval and the control group after 4 weeks. The increase in the KAATSU group was higher than that of the other two groups. The increase was 93.12%, 96.45%, 28.99 for KAATSU intensive interval, intensive interval and control group respectively. In addition, compared to the control group, there was a significant difference between KAATSU intensive interval and intensive interval in the post-test of the minimum, the maximum and the average anaerobic power. But the difference was not significant between KAATSU intensive interval and intensive interval. The increase in the power output was in line with the most of the studies carried out so far[11, 16-19]. The reason for the significant difference in the minimum, the maximum and the average anaerobic power in KAATSU intensive interval compared with the other groups, can be the simultaneous use of KAATSU exercise and intensive interval which brings about higher neurotic-muscular adaptation compared with using just one type of exercise.

The results of the present study regarding the insignificant change in the minimum, the average and the maximum anaerobic power of the intensive interval are not similar to those of the Zimen’s. This difference in results may be due to different exercise protocols used in the two research studies or the number of exercise sessions in a week because the intensive interval exercise in the study carried out by Zimen et al., was performed during 6 weeks on active males including 6 sets of pedaling each one for 90 seconds. It was in 80% of the maximum oxygen consumption with 180 seconds of active rest and 3 sessions a week. The results of the mentioned study indicate the significant increase in the maximum oxygen consumption, the average and the maximum anaerobic power[8]. The study conducted by Abe et al., suggested that performing KAATSU exercise for 8 weeks increase the participants’ speed.

Compared to the intensive interval, participating in the KAATSU intensive
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interval alone has a higher influence on the tiredness index, the maximum anaerobic power (Wingate bicycle), the minimum and the average anaerobic power.

References:

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