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INTERACTION BETWEEN FOOD SUPPLEMENTS ATHLETES USE FOR IMPROVMENT
A SYSTEMATIC LITERATURE REVIEW
MASTER THESIS

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1. **SUMMARY**

Master's thesis by David Margulis " Interaction between food supplements athletes use for improvement: a systematic literature review".

**Aim:** To produce an overview about interactions between supplements that professional athletes use to improve their athletic performance.

**Objectives:** 1. Analyze the interactions and effects of bicarbonate and beta alanine on sports performance and results. 2. Analyse the interactions and effects of bicarbonate and caffeine on sports performance and results. 3. Analyze the interactions and effects of caffeine and beetroot juice/nitrate on sports performance and results.

**Methodology:** Systematic literature review of scientific articles published in English From PubMed Data base Years 2008-2018. To evaluate eligibility PICO criteria was used: 1. **Population:** professional athletes undertaking specific training for a sport/event, ages 18-45 were included. Studies with diseased state individuals and animals were excluded. 2. **Intervention:** adding 2 dietary supplements to diet and interactions between these supplements. Articles dealing with sportsman using illegal supplements were excluded. 3. **Comparison:** no using supplements/ using placebo/ using one supplement. People who are not sportsman and take supplements were excluded. 4. **Outcome:** All possible outcomes of food supplementation for sport performance and health. Outcomes which are not related to sports and health were excluded.

**Results:** 1014 (678+177+159) articles were found in total in 3 separate searches from which 7 (3+2+2) articles were taken from PubMed database, using the key words: "Athletes", "Beta-Alanine", "Caffeine", "Beetroot juice/Nitrate" With the use of the combinations: “athletes use bicarbonate and beta alanine/bicarbonate and caffeine/ caffeine and beetroot juice".

**Conclusions:** According to scientific literature (2008-2018) analysed in this study we can conclude: 1. Sodium bicarbonate in combination with beta alanine may be beneficial in sports where the body use anaerobic glycolysis like judo and jujitsu and in exercises involving the upper body musculature more than lower body. 2. Sodium bicarbonate in combination with caffeine, was beneficial in studies done on Judo sportsman and there was importance of the supplementation protocol. It is better to take it in separate doses because in one dose it may cause some gut disturbances. The consumption of both supplements together increased blood lactate. 3. Caffeine in combination with beetroot juice/nitrate, more studies needed to be performed on the combination of these food supplements in sports because it was not clear whether there is benefit in using these supplements together. 4. There is a lack of good quality scientific literature on the combination of food supplements and more research should be done.
ABREVIATIONS

Cr- creatine
BA- beta alanine
BJ- beetroot juice
SB- sodium bicarbonate
GI- gastrointestinal
Sjft- special judo fitness test
TT- time trial
PL- placebo
LD- loading dose
MD- maintenance dose
RCT- randomized controlled trial
2. INTRODUCTION

Dietary supplement is a food, food component, nutrient, or non-food compound that is purposefully eaten in order to improve performance, recovery and health [2]. Information about the use of supplements among athletes is usually provided by their coaches or doctors [3]. There are some differences between countries and areas regarding the use of supplements but approximately half of US population uses supplements and the use of supplements increase with age (an estimated 104 billion dollars market on 2013) [1]. There is usually a protocol that is recommended for the use of supplement however the protocol is for the supplement alone and it often fails to predict the interaction between the supplements the athlete takes [4].

The aim of this study is to produce an overview about interactions between supplements that professional athletes use to improve their athletic performance with the use of the last scientific publications (2008-2018).

The objectives of this study:

1. Analyse the interactions and effects of bicarbonate and beta alanine combination on sports performance and results.
2. Analyse the interactions and effects of bicarbonate and caffeine combination on sports performance and results.
3. Analyse the interactions and effects of caffeine and beetroot juice/nitrate combination on sports performance and results.
3. LITERATURE REVIEW

According to the Australian Institute of Sport, nutritional supplements can be classified based on performance effect [4].

High level of evidence: They will improve athletic performance with adequate dosing and specific types of effort- Beta alanine, Sodium bicarbonate, Caffeine, Creatine, Beetroot juice.

Moderate level of evidence: May improve performance, under specific dosing and effort conditions, although additional research is required- Fish oils, Carnitine, Curcumin, Glucosamine, Glutamine, HMB, Quercetin, Vitamin C and E, Tart cherry juice. Low level of evidence: no shown beneficial effects- supplements not found in other categories. Illegal supplements: might lead to positive doping tests and therefore are not authorized- substances on the list printed annually by the “World Anti-Doping Agency”.

Dietary supplements come in many forms:

1. Functional foods, foods enriched with additional nutrients or components outside their typical nutrient composition (e.g., mineral-fortified and vitamin-fortified, as well as nutrient enriched foods)

2. Developed foods and sports foods, merchandise providing energy and nutrients in a very additional type than traditional foods for general nutrition support (e.g., liquid meal replacements) or for targeted use around exercise (e.g., sports drinks, gels, bars)

3. Single nutrients and other components of foods or herbal products provided in isolated or concentrated forms

4. Multi-ingredient products containing various combinations of those products described above that target similar outcomes [1].

5. Not all supplements have scientific approval and meta-analysis and systematic reviews have much more scientific power than case reports case studies or ideas and experts opinion for example [1].

6. The prevalence of supplement use is slightly higher among men [2].

7. Research of the combined use of different supplements together and the repeated use of supplements is lacking [1].
In my thesis I have chosen to talk about supplements with high evidence of effectiveness according to the most recent studies, which athletes use in order to improve their performance and to check if their combinations are beneficial for sports performance and results. Current knowledge regarding the supplement’s athletes use to enhance competitive performance is presented in table 1.

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Mechanism of action</th>
<th>Recommended Dosage and possible sports field of usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatine[4][5]</td>
<td>Increases intramuscular Creatine concentration which can improve exercise performance</td>
<td>Loading 5 days with 20g/day or taking a month 3g/day. Example of sports: Team sports, racket sports, combat sports, heavy weight lifting.</td>
</tr>
<tr>
<td>Caffeine[6][7][5]</td>
<td>Reducing fatigue and increase wakefulness and alertness</td>
<td>3-6mg/kg per day is considered safe. Examples of sports: Swimming, rowing, cycling, combat sports.</td>
</tr>
<tr>
<td>Nitrate/Beetroot juice[8][9][10]</td>
<td>Reduces the amount of oxygen that is needed to perform exercise, and in some situations can increase exercise tolerance and performance.</td>
<td>8 mmol taken 2h before event. Example of sports: athletics, swimming, rowing</td>
</tr>
<tr>
<td>Beta alanine[11][12]</td>
<td>Increases intramuscular carnosine concentration which acts as intracellular pH buffer, improves exercise performance and decreases fatigue after exercise</td>
<td>4 weeks of 4-6g/day. Example of sports: High intensity sports like swimming and rowing Sports which require high intensity training.</td>
</tr>
<tr>
<td>Bicarbonate[13][14]</td>
<td>A buffering agent that improves performance by enhancing the H+ efflux from working cells and tissues</td>
<td>0.2-0.4g/kg 60-120min before exercise. Example of sports: team sports, combat sports, athletics.</td>
</tr>
</tbody>
</table>
There is a scientific discussion that combining sport food supplements can have different effects:

1. **Additive benefits for the same goal:** Taking a combination of supplements may be more beneficial than taking each supplement alone for the purpose of usage, for example combining β-alanine and bicarbonate may increase the buffering capacity and decrease acidosis related with athletic performance [16].

2. **No additive benefit for the same goal:** The benefits of taking a combination of supplements may not be evident because the action of each individual supplement is already bringing the body to its maximal capability, for example reaching the maximal buffering capacity with bicarbonate and no benefit from the addition of beta alanine [16].

3. **Autonomous mechanism with opposing outcomes:** supplements with different mechanisms of action can negatively influence on each other, for example taking bicarbonate together with caffeine may increase the risk of gastrointestinal side effect which are associated with bicarbonate intake, and may lead to opposite results from what we are trying to achieve on the athletes performance [17].

4. We presented some opinions of individual researchers. To get the full picture, we decided to make a systematic literature review.
4. METHODOLOGY

A systematic literature review has been performed to investigate the interactions between supplements that professional athletes use to improve their athletic performance.

4.1. Search strategy

A systematic literature review was performed while searching for different studies from PubMed database. The publications which were relevant to the study, and contain interactions between two supplements were identified with key words. “Athletes”, "Beta-Alanine", "Caffeine", "Beetroot juice/Nitrate" With the use of the combinations: “athletes use bicarbonate and beta alanine/bicarbonate and caffeine/ caffeine and beetroot juice”

4.2. Eligibility criteria (PICO)

4.2.1. Population: professional athletes undertaking specific training for a sport/event, ages 18-45 were included. Studies with diseased state individuals and animals were excluded.

4.2.2. Intervention: adding 2 dietary supplements to diet and interactions between these supplements. Articles dealing with sportsman using illegal supplements were excluded.

4.2.3. Comparison: no using supplements/ using placebo/ using one supplement. People who are not sportsman and take supplements were excluded.

4.2.4. Outcome: All possible outcomes of food supplementation for sport performance and health. Outcomes which are not related to sports and health were excluded.

4.3. Studies selection

Study selection was completed between September 2018 and December 2018, including studies made from 2008 till 2018. The searching process was divided into 3 separate sections, each one according to one objective. The first objective was to analyse interactions between bicarbonate and beta alanine in athletes, the searching combinations "Athletes use bicarbonate and beta alanine", "bicarbonate and beta alanine" and "bicarbonate and β-alanine" were used in order to cover all the options.

After filtering according to all inclusion and exclusion criteria 3 studies were selected. The same was done with the other two objectives but for the combination of supplements "bicarbonate and caffeine" and "caffeine and nitrate/beetroot juice"(here the searching was with the combination of nitrate and then with beetroot juice in order not to miss any articles). The detailed flow chart showing the process of study selection is presented on Fig.1.
Identification
PubMed
1014 articles were found in total after all searching combinations

Screening
126 articles were left after filtering: only full text, only from last 10 years, only on humans

Eligibility
119 articles were excluded from the study after filtering with inclusion and exclusion criteria

Included
7 articles were included

Fig. 1. Flow chart showing the process of study selection
4.4. **Quality of selected studies**

A quality assessment key was developed to score the studies. Included studies were scored 0, 1, or 2 for each of the eight scale items with a maximum total score of 16 points. This method is a modified version of Altman DG et al study where it is explained how to measure the quality of randomized control trials[15]. Overall quality scores were converted to a percentage value and rated (0–49% = poor, 50–89% = moderate, and [90% = good).

*Study quality score key: Total score (16, 100%)*

1. **What study design was used and, and how were participants allocated?**
   2 = mixed design, randomized and counterbalanced between conditions
   1 = repeated measures/within subjects only OR mixed design but not randomized.
   0 = between groups only

2. **Was the assigned intervention concealed before allocation?**
   2 = adequate
   1 = unclear
   0 = inadequate/impossible

3. **Were the outcome assessors blinded to treatment status?**
   2 = Effective action taken to blind assessors
   1 = Small or moderate chance of unbinding of assessors
   0 = Not mentioned or not possible

4. **Were the inclusion and exclusion criteria clearly defined?**
   2 = clearly defined
   1 = inadequately defined
   0 = not defined

5. **Were the intervention and control group comparable at entry?**
   2= good comparability of groups, or confounding adjusted for in analysis/within group design
   1= confounding small; mentioned but not adjusted for
   0= large potential for confounding, or not discussed
6. Were the interventions clearly defined?
2 = clearly defined interventions were applied
1 = clearly defined interventions were applied but the application was not standardized
0 = intervention and/or application were poorly or not defined

7. Were the outcome measures used clearly defined?
2 = clearly defined
1 = adequately defined/recorded
0 = not adequately defined/recorded

8. Was the follow up period sufficient to measure the effects of the intervention?
2 – active surveillance and appropriate duration
1 – active surveillance, but inadequate duration
0 – surveillance not active or not defined
5. RESULTS AND THEIR DISCUSSION

Relevant and detailed information was extracted from the studies that met all the inclusion and exclusion criteria and was put into a table 2. Included studies were reviewed based on the following characteristics: the participants and their field of sport, the intervention which was performed during the study, what was the method of evaluation of the effect of the intervention, what was the outcome of the intervention.
<table>
<thead>
<tr>
<th>Participants</th>
<th>Intervention</th>
<th>Method of evaluation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beta Alanine and Sodium Bicarbonate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additive effects of beta-alanine and sodium bicarbonate on upper-body intermittent performance. Tobias, Gabriel et al. 2013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>37 male Judo and jujitsu athletes</strong></td>
<td>BA+PL (n=10) PL+SB (n=9) BA+SB (n=9) PL+PL (n=9) (500mg/kg/day sodium bicarbonate, 6.4g/day beta alanine)</td>
<td>Combat sports simulation 4x30s upper body Wingate tests with 3 min recovery</td>
<td>Beta alanine resulted in 7% improvement compared to placebo. Bicarbonate resulted in 8% improvement compared to placebo. Combination resulted in 14% improvement compared to each supplement alone.</td>
</tr>
<tr>
<td><strong>Effect of Beta Alanine and Sodium Bicarbonate supplementation on repeated-sprint performance. Ducker et al. 2013</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>24 male competitive team sport athletes</strong></td>
<td>BA only SB only BA+ SB Placebo only (300 mg/kg sodium bicarbonate 60 min pre-exercise, 80mg/kg beta alanine)</td>
<td>Team sport simulation 3 sets of 6x20 m sprints on 25s with 45s recovery</td>
<td>Beta alanine alone produced little effect. Bicarbonate produce &quot;very likely&quot; improvement. Combination of them reduced the improvement was seen with bicarbonate alone.</td>
</tr>
<tr>
<td><strong>Effect of Combined A-Alanine and Sodium Bicarbonate Supplementation on Cycling Performance. Bellinger et al. 2011</strong></td>
<td>14 highly trained male cyclists</td>
<td>Placebo+ Placebo Beta alanine+ placebo Placebo+ sodium bicarbonate Beta alanine+ sodium bicarbonate (300 mg/kg sodium bicarbonate, 65 mg/kg/day beta alanine)</td>
<td>Cycling 4 minutes ergometer</td>
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</tr>
</tbody>
</table>

| **Sodium Bicarbonate and Caffeine** | 12 international level Men rowers | Caffeine (pills, 3mg/kg) Sodium bicarbonate (0.3g/kg, in capsules) Caffeine+ Sodium bicarbonate (at the same doses described above) Placebo (dextrose + calcium) | Each rower performed four 6-minute maximal rowing tests (the maximal distance they can cover in 6 min) after being supplemented with one of the possible interventions | Caffeine- improvement Relative to placebo Caffeine and Caffeine + Bicarbonate- improvement Bicarbonate no improvement |
### Separate and Combined Effects of Caffeine and Sodium-Bicarbonate Intake on Judo Performance. Felippe et al. 2016

<table>
<thead>
<tr>
<th>10 Judokas Men</th>
<th>4 supplementation protocols: (with 1 week for washout between them)</th>
<th>3 special judo fitness tests (applying a throwing technique) interspaced with 5 minutes rest</th>
<th>The combined supplementation of Sodium Bicarbonate+Caffeine increases judo performance compared to placebo. Caffeine alone and Sodium bicarbonate alone also showed better performance then placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sodium Bicarbonate (0.3g/kg in 3 separate doses)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caffeine (6mg/kg 1 hour before the test)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sodium Bicarbonate+Caffeine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Placebo (cellulose)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Caffeine and Beetroot juice/Nitrate

**Effects of dietary nitrate, caffeine, and their combination on 20-km cycling time trial performance. Glaister et al. 2015**

<table>
<thead>
<tr>
<th>14 competitive female cyclists</th>
<th>Beetroot juice (0.45g of dietary nitrate)</th>
<th>20- km cycling</th>
<th>There is significant improvement in performance with caffeine supplementation, without any benefits from nitrate relative to placebo. Combination- no benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Caffeine (5mg/kg in capsule)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beetroot juice +Caffeine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Placebo (Beetroot juice with nitrate removed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 male and female competitive cyclists</td>
<td>Caffeine gum (3mg/kg 40 min before test)</td>
<td>Concentrated beetroot juice (8.4mmol 2h before test)</td>
<td>Caffeine+ beetroot juice</td>
</tr>
</tbody>
</table>
5.1. Characteristics of selected studies

The ranking of the selected studies is presented in table 3. The studies employed a mixed design, randomized and counterbalanced between conditions. These study designs allowed most studies to have groups which were comparable at baseline. Adequate description of inclusion and exclusion criteria was lacking in the last study by Lane et al. The intervention was well defined in the selected studies and the duration was adequate.

<table>
<thead>
<tr>
<th>STUDIES</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>SCORE</th>
<th>QUALITY RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tobias G et al (2013)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>2. Ducker KJ et al (2013)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>3. Bellinger et al (2011)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>4. Christensen PM et al (2013)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>5. Felippe LC et al (2016)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>6. Glaister et al (2015)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>good</td>
</tr>
<tr>
<td>7. Lane et al (2014)</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>moderate</td>
</tr>
</tbody>
</table>

From the beginning only studies on athletes were included (written in the inclusion criteria) because in my opinion studies on the regular population can be biased in many ways, for example we can't know what is the level of fitness of the individual, and whether this level influences the effect that the supplement has on his body. When making a research on professional athletes I can assume that they start from the same point or very close, minimizing the risk of biased results.

The population in most of the studies were men and small groups of athletes were participating, on one side it increases the chance that athletes have similar baseline characteristics however on the other side- the smaller the population of the study the more challenging it is to make conclusion on the bigger population.

5.2. Beta alanine and sodium bicarbonate

3 studies that met the inclusion and exclusion criteria were found, a total of 75 athletes were investigated, the sport fields were judo, jujitsu, cycling and sprinting. The quality of the studies was good.

Tobias G et al. said that the combination of BA and SB showed much greater improvement in comparison to taking this supplement individually. Both supplements increased blood lactate. SB showed the same effectiveness when taken chronically and acutely. BA is studied not for a long period of time and there were some contradictory conclusions, the most recent analysis showed that it is
effective[18]. The data from Tobias G et al. suggest that BA and SB have the same effectiveness and there is no superiority between them[18]. It was shown that arm exercises are more sensitive to this supplements combination maybe because arm exercises produce more acidosis[18]. The fitness status of the athlete could influence the performance of the supplements on him because more fit individuals might have more muscle buffering capacity, however tested judo and jujitsu athletes who likely have high muscular buffering capability showed positive results in the BA+PL group[18]. Tobias G et al. told that there was a reduced feeling of recognizable exertion when SB and BA were taken together but not when taken separately. This effect may be due to the reduction of pH but it is needed to be studied further[18]. Supplementing with sodium bicarbonate 0.3g/kg one hour before exercise which involves repeated sprinting for example soccer may be beneficial however supplementing with BA may be not effective for these sports which require rapid bouts of sprinting with not long time to recover after[16]. Combining SB with BA is not recommended because sodium bicarbonate alone showed more improvement[16].

Bellinger et al. said in the study that 28 days of beta alanine use did not significantly improved cycling performance, but there was small beneficial effect which might support the use of beta alanine in highly trained cyclists[19]. Acute bicarbonate supplementation benefit was significant in 4 min cycling performance, however there was minimal effect from the combination of sodium bicarbonate and beta alanine together[19].

In summary, Sodium bicarbonate in combination with beta alanine may be beneficial in sports where the body use anaerobic glycolysis like judo and jujitsu and in exercises involving the upper body musculature more than lower body. The data presented is reliable however more studies have to be performed especially on women because most of the participants were men.

5.3. Sodium bicarbonate and caffeine

Two studies that met the inclusion end exclusion criteria were found, a total number of 22 athletes were investigated in the fields of judo and rowing, the quality of studies was good however there weren't studies on female athletes. Caffeine and sodium bicarbonate were studied in number of studies which showed their beneficial effect for high intensity endurance sports[6][13]. In professional sports as world class rowing for example many times the difference between the first and second place may be a matter of seconds and therefore supplementations that can even minimally improve the performance of the athlete may be beneficial In London 2012 Olympics, less than 2 seconds separated between the first and the second place in some of the rowing competitions [20]. Supplementation of caffeine together
with sodium bicarbonate was beneficial in 6 minute maximal rowing in highly trained athletes[20]. Lower performance level may lead to higher variability in the measurement of performance[20].

The findings of Christensen et al. show that high performance athletes and their coaches should consider using caffeine in doses of 3mg/kg of body mass in non-fasted state[20].

2 of the "non responders" to caffeine were athletes who drink coffee on daily bases, however in the group of the responders there were also low and moderate coffee drinkers, although all the study participants were asked to stop using caffeine containing beverages 36 hours before the study[20]. SB group showed no better results than the placebo group[20].

Christensen et al. said that caffeine alone showed a positive ergogenic effect however the addition of SB had no positive or negative influence in elite rowers performing maximal 6 minutes rowing[20]. Anaerobic glycolysis is used in the body in intermittent sports actions including judo[21]. Elevation in anaerobic glycolysis is responsible for elevation of both blood and muscle H+ which may cause fatigue and therefore reduction of pH possibly with bicarbonate may be beneficial[17]. Caffeine causes decreased perceived exertion[17].

Caffeine increases the production of catecholamines which increase the anaerobic glycolysis in the muscle, causing elevated pH[17], therefore it is reasonable to assume that combination of caffeine together with bicarbonate would have beneficial effect. Bicarbonate supplementation together with caffeine increased the number of throws in judo athletes during 3 SJFTs[17].

There is importance in the supplementation protocol as some protocols showed gut disturbances in the athletes, divided doses appear to minimize the gastrointestinal side effects [17]. The consumption of caffeine and SB together or separately increased blood lactate [17]. Only the combination resulted in more throws and there is a suggestion that SB with caffeine increase the uptake of K+ by muscle fibres and it may be further increased with the combination of the supplements but further studies need to be performed on this suggestion[17].

In summary, Sodium bicarbonate in combination with caffeine, was beneficial in studies done on Judo sports man and there was importance of the supplementation protocol. It is better to take it in separate doses because in one dose it may cause some gut disturbances. The consumption of both supplements together increased blood lactate. The data presented was reliable however there were no studies done n women.

5.4. Caffeine and nitrate/beetroot juice

Two studies met the inclusion and exclusion criteria, a total of 26 athletes were investigated, all in competitive cycling, the quality of studies was good and here compared to the previous studies, most of the participant were women. Nitrate is abundant in green leafy vegetables and its
supplementation reduces the oxygen consumption and increase exercise tolerance and performance[22]. Caffeine has well established benefit, and there is a clear evidence that it has positive ergogenic help for different kinds of sports[6].

In a 20 kilometres of cycling in well trained professional athletes in comparison to placebo, the results showed a positive effect of caffeine supplementation but no effect of nitrate[23]. It is possible that the absence of effect of nitrate is due to the high intensity of the trial and it is also possible that the dose was too small to produce effect, however the level of nitrate in the blood of the tested subjects were high which makes this assumption unlikely[23].

Even though the positive effect caffeine had, when it was combined with nitrate this effect was cancelled, suggesting that there is a possibility that there is negative interaction between the supplements[23].

When comparing to placebo, heart rate and blood lactate when taking the combination of supplements, was similar to that of caffeine alone which shows that probably there is small effect from the addition of nitrate[23]. Possible interactions between caffeine and nitrate in the blood has not been investigated and in this study they were taken separately, this issue needs to be checked in future studies[23]. On the trial performed simulating the cycling TT in London Olympic games 2012, the results showed that caffeine supplementation showed positive results to both male and female cyclists, however BJ didn't provide any detectable benefit[24].

The results were visualized in those cyclists mentioned above but they can be generalized to athletes undertaking similar sport[24]. Caffeine improved athletes performance under the same basic properties and conditions that athletes who practice professional cycling are in, for example, carbohydrate reach meal before the exercise, which makes the study more reliable and similar to the real world[24]. Baxter R et al. said that caffeine influence was reduced when it was combined with carbohydrates in previous studies but it was not the case in this study[24]. There is no need to withdraw caffeine from regular coffee drinkers in order to enhance its positive ergogenic effect[24]. In contrast to caffeine, BJ had no effect in this study and the conditions where BJ has positive effect remain unclear and things that are might be important to check is the timing, dosing, intensity and duration of exercising protocol and the level of fitness of the athlete[24]. The effect of BJ on exercise capacity is dose dependent with maximal value seen with the ingestion of two bottles of concentrated BJ which contain 8.4 mmol[8].

However this was not the case with the cyclists who took the same amount without similar benefits, which shows that the lack of effect cannot be explained by dosing[24]. It is
not yet known if the mechanism of reduced oxygen consumption improves the athletes exercise capabilities in the range of athletic fields and intensities, however nitrate showed some benefit in 5-30 minute cycling trials[24]. The more difficult the exercise is the more hypoxia it produces within the skeletal muscle, and there might be a connection between the intensity of the exercise and the influence of nitrate supplementation, more studies should be done on that question[9][24]. The difficulty to show a positive effect from nitrate supplementation may be because of studies done on highly trained athletes, studies and meta-analysis done on recreationally active individuals showed more pronounced positive effect[24]. It is possible that longer duration of supplementation with beetroot juice is needed in order to produce effect[24].

In summary, this systematic review shows that there are supplements that show beneficial outcomes for the athletes, repeatedly in the majority of the studies, and there are supplements that show a minor impact and need to be studied further moreover caffeine and nitrate studies included only women and more studies on men should be performed. However, there are supplements that were studied much more than others, and sometimes on very small groups of athletes which might have some impact on the final results, therefore more studies needed to be performed when the question of effectiveness is still not completely answered. Athletes and coaches need to consider according to the current information whether it is reasonable, cost effective and beneficial for them to use this supplement.
6. CONCLUSION

According to scientific literature (2008-2018) analysed in this study we can conclude:

1. Sodium bicarbonate in combination with beta alanine may be beneficial in sports where the body use anaerobic glycolysis like judo and jujitsu and in exercises involving the upper body musculature more than lower body.

2. Sodium bicarbonate in combination with caffeine, was beneficial in studies done on Judo sports man and there was importance of the supplementation protocol. It is better to take it in separate doses because in one dose it may cause some gut disturbances. The consumption of both supplements together increased blood lactate.

3. Caffeine in combination with beetroot juice/nitrate, more studies needed to be performed on the combination of these food supplements in sports because it was not clear whether there is benefit in using these supplements together.

4. There is a lack of good quality scientific literature on the combination of food supplements and more research should be done.
7. **PRACTICAL RECOMMENDATIONS**

1. Supplementation might have minor but critical beneficial effect.

2. Taking supplements together might have a beneficial positive effect however they can also interfere with each other's action.

3. SB can be used with BA in sports involving upper body musculature more than lower.

4. SB with caffeine may be beneficial if used according to specific protocol and taken in separate doses to avoid gut disturbances.

5. According to the current knowledge the data is controversial with regard to the combination of BJ and caffeine, one study says that it is beneficial and the other not, my recommendation is to wait for more studies to be done on this combination.
8. REFERENCES


