ACUTE CAFFEINE SUPPLEMENTATION RETARDS AEROBIC AND LACTIC ANAEROBIC PERFORMANCE DECLINE FOLLOWING A SIMULATED FUTSAL PROTOCOL

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Abstract

The aim of this study was to examine the effect of caffeine supplementation on aerobic, lactic anaerobic and alactic anaerobic performances in male futsal plyers following a simulated futsal match. **Methods:** Twenty trained futsal players (age= 34.05±3.7 yr., weight=74.38±8.65 kg, height= 1.75± 4.3 cm, body fat%=20.82±5.6 and BMI=24.15±2.62 kg/m^2) participated in this single group, placebo controlled and single blinded study. The participants conducted two simulated futsal games with 1 week break between them after ingesting either caffeine (3mg/kg body mass) or placebo. The subjects consumed the same food 24 hr. before each protocol. At the baseline and immediately after two protocols, alactic anaerobic, lactic anaerobic, and aerobic performances were assessed using Sargent jump test, Running based anaerobic sprint (RAST) test and 5 minutes running field test as a measurement of maximal aerobic velocity, respectively. The data were analyzed using repeated measures of analysis of variance.**Results:** After futsal simulation under caffeine or placebo condition, There were no significant ($p \geq 0.05$) differences on alactic anaerobic performance compared to baseline, and alactic anaerobic power output was not significantly($p \geq 0.05$) different between two conditions after simulated protocol. After futsal simulation, aerobic and lactic anaerobic performances for caffeine and placebo conditions were significantly ($p \leq 0.05$) lower that the baseline. Post protocol aerobic and lactic anaerobic performance measures were found significantly ($p \leq 0.05$) higher in the caffeine condition than that of in the placebo.**Conclusions:** Based on these results it can be said that 3 mg/kg body mass acute caffeine supplementation retards aerobic and lactic anaerobic performances decline after simulated futsal protocol. But it is not clear whether these ergogenic effects influence performance during futsal game. Therefore, the results need to be confirmed during simulated and true futsal games.

Keywords: Futsal, caffeine, alactic anaerobic power output, anaerobic power output

Introduction

Futsal is known as an intense sport among the team sports which rely on speed, strength and endurance capabilities. This indoor sport requires high levels of physical and physiological abilities. Researchers have studied the aerobic and anaerobic demands of futsal match and the effects of different training methods on these metabolic pathways ((Barbero-Alvarez, Soto, Barbero-Alvarez, & Granda-Vera, 2008).

Barbero et al (2008) have documented the intermittent high intensity nature of futsal game with possibility of strong reliance on aerobic and anaerobic systems. Dogramaci et al. (2011) have shown that 26% of total distance is covered by high intensity movement activities during a futsal match and cardiovascular challenges may reach up to the 85-90% of HRmax or higher. Alvarez el al (2009) carried out a study related to the aerobic fitness of futsal players at different competitive levels. Other researchers have also compared aerobic fitness of professional, semiprofessional futsal players (Alvarez, D'ottavio, Vera, & Castagna, 2009). These authors concluded that the aerobic fitness is strongly related to the competitive levels of futsal players (Dogramaci, Watsford, & Murphy, 2011, Alvarez, D'ottavio, Vera, & Castagna, 2009).

On the other hand, the most key actions in futsal, such as shooting, tackling, blocking and quick changes of direction, have high intensity feature and are performed at very short duration(<5s), which indicating the pivotal role of alactic anaerobic ability in this sport (Leite, 2016). Lactic concentrations in blood reach 5.3- 5.5 mmol/L during futsal game and successful futsal players show also higher lactic anaerobic fitness than soccer players (Gioldasis, 2016). Respect to the aerobic and anaerobic metabolic pathways contributions to energy release during futsal game, scientists have focused on boosting these metabolic pathways through various supplements. In the study relating to the effects of creatine monohydrate supplementation on motor performance in female futsal players, it has been found that creatine monohydrate supplementation (20 gr/ day for 5 days followed by 5gr/day for 10 days) has positive effects on speed, agility and explosive power (Harmancı, Kalkavan, Karavelioğlu, & Şentürk, 2013). Karavelioglu (2014) investigated the effects of sodium bicarbonate supplement in female futsal players and concluded that the supplement can reduce blood lactate and increase distance covered during a yo-yo intermittent test.

Caffeine as a plant alkaloid has been used to improve cognitive and exercise performance over the last decade and positive effects of caffeine supplementation on work output and exhaustion time have been documented by Studies on caffeine and endurance performance (Sökmen, Armstrong, Kraemer, Casa, Dias, Judelson, & Maresh, 2008). It has been established that caffeine induces ergogenic effect during short term intense activities (Sökmen, Armstrong, Kraemer, Casa, Dias, Judelson, & Maresh, 2008). While, the findings on caffeine and power and sprint events are to some extent inconsistent (Sökmen, Armstrong, Kraemer, Casa, Dias, Judelson, & Maresh, 2008). The controversy may root from limited number of studies and reflects need for further study in this area. Moreover, in spite of reliable findings on positive effects of caffeine supplementation on aerobic and lactic anaerobic performance, no study was found in the literature that investigated the effects of caffeine supplementation during a simulated futsal game. It is noteworthy that response to caffeine ingestion is variable among the athletes (Spriet, 2014) and the effects of different doses of caffeine need to be studied in stop-and- go sports such as futsal.

Therefore, this study aimed to examine the effects of caffeine supplement on aerobic, lactic anaerobic and alactic anaerobic performance in male futsal players after a simulated futsal game.

Material and methods

Participants

Twenty trained male futsal players (age= 34.05±3.7 yr., weight=74.38±8.65 kg, height= 1.75± 4.3 cm, body fat%=20.82±5.6 and BMI=24.15±2.62 kg/m^2) form 14 futsal teams competing in the Zanjan provinc (Iran) educational departments championship voluntarily participated in this study. They had all experience of futsal training (3 times a week) for at least 5 years and were not regular caffeine user. The subjects informed about the aim and possible risks of the study, and singed the informed consent. The study was conducted in accordance with the declaration of Helsinki and approved by ethic committee of the Islamic Azad University of Zanjan branch.

Study design

A single group, single blinded and repeated measures design was used to examine the effect of caffeine supplementation. One week prior to the simulated futsal game, the baseline assessments were conducted as follow:

Dietary intake: dietary intakes were assessed using 24 hour dietary recall on three days (1 weekend and 2 week days). Energy and macronutrient (protein, fat and carbohydrate) intakes were determined by Nutritionist Pro software (Pikosky, Gaine, Martin, Grabarz, Ferrando, Wolfe & Rodriguez, 2006). Twenty four hours prior to the simulated futsal protocol either at placebo or caffeine condition, the caloric and macronutrient intake was equal to the baseline for each subject.

Anthropometric Measurements: all the anthropometric measurements were conducted based on standard methods. Height and weight were assessed with barefooted and minimal clothing using tape measure attached to the wall and Sahand digital scale (Iran), respectively.

Sargent jump test: after appropriate warmup, the subject stood side on to a wall and reached up with the hand closest to the wall. The feet flat kept on the ground, the point of the fingertips was marked. The subject then stood away from the wall, and jumped vertically as high as possible using both arms and legs. The highest touch point was marked. The difference between standing reach point and highest touch point was considered as jumping score. Alactic power output was calculated using Harman formula (Carpenter, 2014).
Peak power (W) = (61.9 × jump height (cm)) + (36.0 × body mass (kg)) – 1.822

Running based anaerobic sprint (RAST) test: after 5- min active rest period, each subject weighed prior to the test. The test was including of 6× 35m sprint with a 10s recovery between each sprint. Two stopwatches were used to time the each 35m sprint and 10s recover interval. Average lactic power output was calculated as follow (Cipryan & Gajda, 2011):
Power=Weight x $Distance^2 \div Time^3$
Average power (W) = the sum of all six values divided by 6

5 minutes running field test as a measurement of maximal aerobic velocity test ($V_{amax\ (5)}$): Berthon et al (1997) had reported that 5- min test provides reliable measure on maximal aerobic velocity. After 18-min active rest period, the subjects conducted a 5 –min maximal run test. They were asked to the maximal distance on track. A sound signal was given every minute and maximal aerobic velocity ($V_{amax\ (5)}$) was calculated in meter per second (Berthon, Fellmann, Bedu, Beaune, Dabonneville, Coudert & Chamoux, 1997).

Placebo trail

Twenty four hours prior to the placebo trail, the subjects received the same amount of calorie as the baseline. Subjects arrived at lab at 1 p.m., the last meal was eaten at 11:30 a.m., the placebo capsule (3mg/kg body mass starchy) administrated along with 200 ml water at 3 p.m. and the simulated futsal protocol conducted at 4 p.m. after appropriate warmup (15-min).

Simulated futsal protocol: the design of simulated fusel match protocol was adopted from the study of Dal Pupo et al (2017).

The protocol consisted of 2 blocks with 10-min rest period between blocks. There were 6 sets in each block with 3 –min rest interval between set 3-4 and 9-10, and with 9 repetitions in each set without any rest period between them(figure 1B). The protocol consisted of the following intensities: standing (0 $km \cdot h^{-1}$), walking (6 $km \cdot h^{-1}$), jogging (8.5 $km \cdot h^{-1}$), medium-intensity running (13 $km \cdot h^{-1}$), high intensity running (17 $km \cdot h^{-1}$) and sprinting (≥18 $km \cdot h^{-1}$) (Castagna, D'Ottavio, Vera, & Álvarez, 2009). The distance covered (approximately 37 m) and the pattern of movements (forwards running, backwards running and sidestepping running) were the same for the all intensities (Figure 1A) and (figure 1B).

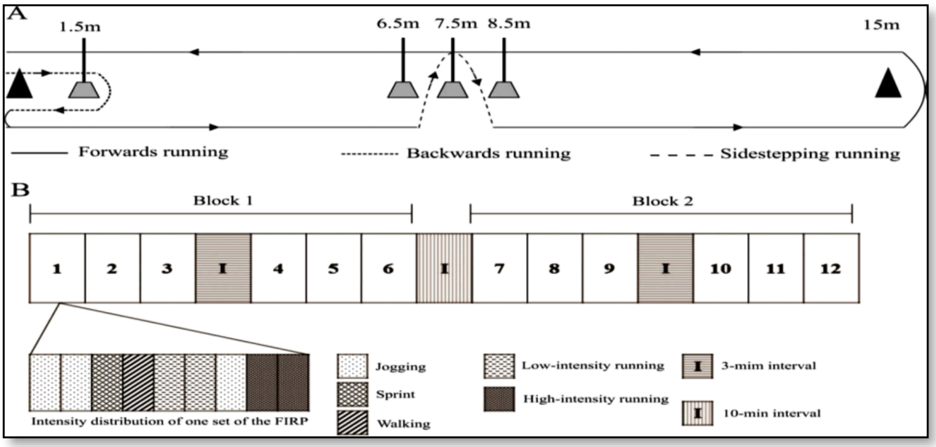

Figure 1. Schematic diagram of simulated futsal, Dal Pupo et al (2017).

The speeds were converted to the $m.s^{-1}$, then, respect to the same distance for each repetition (approximately 37m), the walking, jogging, medium-intensity running, high intensity running and sprinting times were calculated ≈23s, ≈16s, ≈11s, ≈8s and ≈< 8s, respectively. In a pilot study, the tempo of each activity category was regulated using online metronome beats. The movement intensity was maintained by metronome beats during the simulated futsal game.

Post protocol assessments: the subjects preformed Sargent jump test (immediately after protocol), RAST test (following 5-min rest) and $V_{amax(5)}$ test (following18-min rest), respectively.

Caffeine trial

Caffeine trial conducted 1 week after placebo. All subjects were asked to refrain from vigorous exercise 48 hours prior to protocol. All conditions of the caffeine trail (24 hr. calorie intake, simulated protocol and post protocol assessments) were the same as the placebo, except for caffeine capsule (3 mg/kg body mass) which was ingested along with 200 ml water 1 hr. prior to the simulated protocol.

Statistical analysis

Normality of the data verified by shpirovilk test. After checking for sphericity, one way repeated measures analysis of variance with Bonferroni as post hock were used to assess the effect of time on dependent variables. Data were analyzed by SPSS statistical software package version -24 and $p< 0.05$ was considered as statistically significant difference.

Results

Table 1 shows the values for alactic anaerobic, lactic anaerobic and aerobic performances at different time points of measurements.

Table1. Alctic anaerobic, lactic anaerobic and aerobic performance in male futsal players(n=20) under various experimental conditions.

	Alactic anaerobic (w)	Lactic anaerobic (w)	Aerobic($VO_{amax(5)}$), (m/s)
A	7523.32±358.15	456.74±112	3.45±0.50
B	740.16±497.48	428.31±110	3.32±0.45
C	7365.47±506.13	391.67±10	3.22±0.43

A: baseline, B, after futsal simulation under caffeine, C: After futsal simulation under placebo.

No significant differences were found on alactic power output at any time points (baseline, post placebo trial and post caffeine trail) of measurement [F (2, 38) =2.78, P=0.07] (figure2).

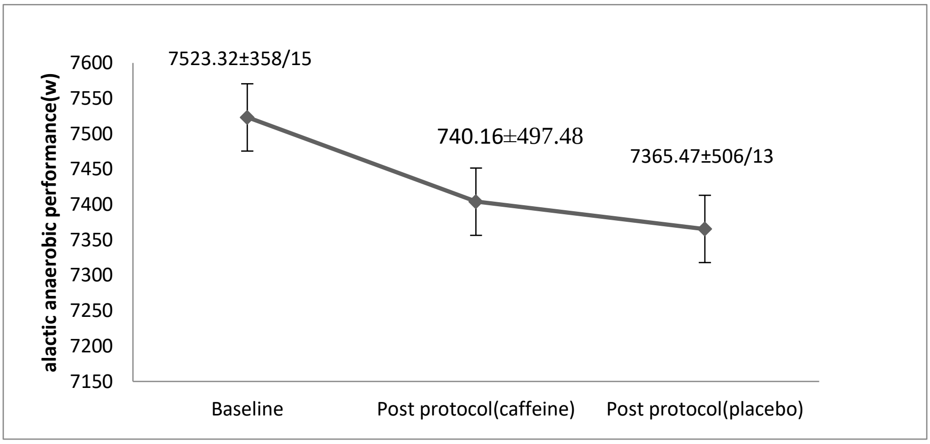

Figure 2: Alactic anaerobic performance changes under various experimental conditions.

Significant differences between conditions were found on lactic anaerobic performance [F (2, 38) = 29.558, P=0.0001] (figure3). Bonfferoni test showed that Post protocol lactic power output were significantly lower than the base line under caffeine (p<o.05) and placebo (p<0.05) conditions. At Post protocol time point, the lactic power output was significantly higher in caffeine condition than in the placebo condition (p<0.05, figure3).

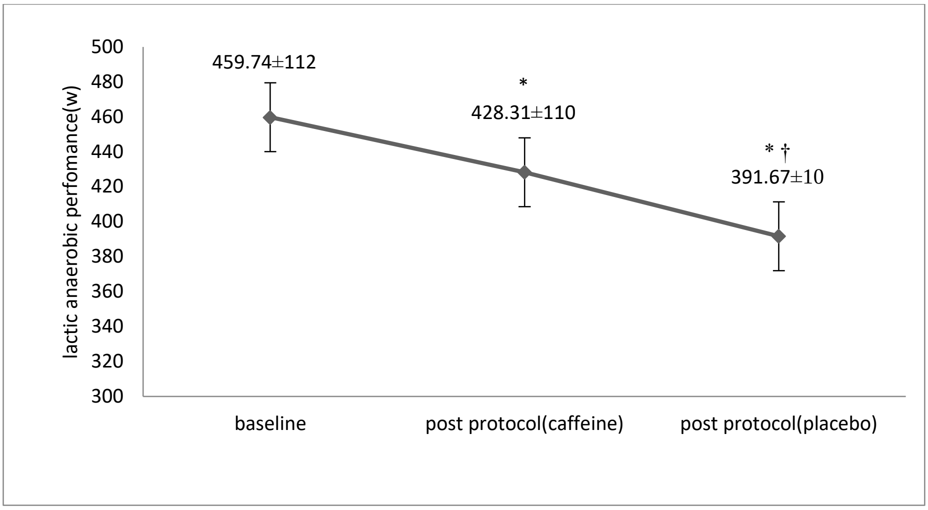

Figure 3. Lactic anaerobic performance changes under various experimental conditions. *, significant difference compared to baseline. †, significant difference compared to post protocol (caffeine).p<0.05.

There were significant differences between $V_{amax(5)}$ measures at three time points[F(2,38)= 54.955,P=0.0001]. After simulated protocol under caffeime or placebo condition, $V_{amax\,(5)}$ was significantly lower compared to baseline ($p<0.05$). After protocol simulation, $V_{amax\,(5)}$ was significantly (<0.05) higher in the caffeine trail than in the placebo trail (figure4).

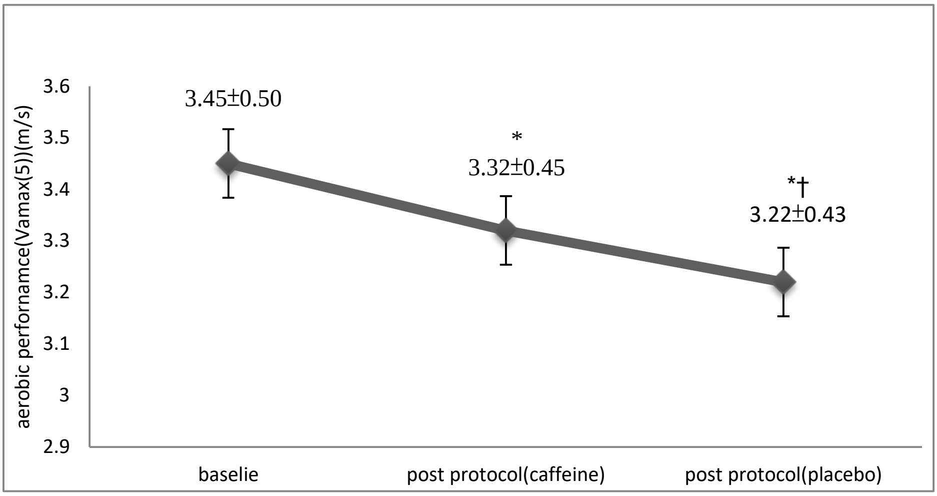

Figure 4: Aerobic performance changes under various experimental conditions. *, significant difference compared to baseline. †, significant difference compared to post protocol (caffeine).p<0.05.

Discussion

The effect of 3 mg/kg caffeine acute supplementation was examined on aerobic and anaerobic performance in this study. Trained male futsal players conducted a simulated futsal protocol following caffeine or placebo ingestion and aerobic, lactic anaerobic and alctic anaerobic performances were assessed immediately after protocols. No significant change was found in alactic anaerobic power after simulated futsal protocol with caffeine or placebo ingestion (figure2). This finding seems interesting, because alactic anaerobic demand of simulated futsal protocol was document by Dal Pupo et al (2017). Milioni et at(2016) demonstrated that metabolites accumulation due to intense exercise did not negatively affect neuromuscular function. Therefore, we think that the lack of metabolites effect on muscle recruitment during explosive actions can be considered as a probable explanation for alactic anaerobic response. In addition, the time gap between the end of protocol and Sargent test, and rapid recovery rate of explosive power can also be involved in this case.

Compared to placebo, acute caffeine ingestion failed to induce any positive effect on alactic anaerobic power after simulated protocol (figure2). In contrast to our finding, sprint measure improvement has been reported after moderate dose (6 mg/kg) of caffeine ingestion in rugby players (Davis & Green, 2009). Pallares et al. (2013) found that a high dose of caffeine (9mlg/kg) improves high velocity muscle actions, but they cautioned about negative side effects. However, ergogenic effects of the low doses of caffeine (≤ 3mg/kg body mass) on sprint activities are unequivocal (Spriet, 2014). In line with our finding, Tucker et al. (2013) did not find explosive power significant change in basketball players after administration of 3mg/kg caffeine. In contrast, Doherty et al (2004) reported that 250 mg (~ 3mg/kg) dose of caffeine could improve maximal anaerobic power during high intensity cycling. It is mentioned that anaerobic power output improvement mediated by the CNS alterations due to the low caffeine doses (Spriet, 2014). The paradoxical effect of low caffeine dose on alactic anaerobic power may be the result of variable subjects' responses to this dosage (Spriet, 2014). To our knowledge, the lack of caffeine effect on alactic power in our subjects was due to the variability in response to a lower dose of caffeine (3mg/kg).

In caffeine and placebo conditions, post protocol lactic anaerobic power was significantly lower relative to the pre protocol, indication of reliance on the lactic system during simulated protocol (figure3). In accordance with our finding the mean blood lactate during a simulated futsal game has been reported 74% of the values during an incremental test, a reflection of the huge amount of energy extraction from lactic system (Milioni,Vieira, Barbieri, Zagatto, Nordsborg, Barbieri, Dos-Santos, Santiago & Papoti, 2016). After simulated protocol, the lactic anaerobic power was found higher in caffeine trail than in the placebo (figure3). Respect to the approximately equal calorie intake and the same physical challenge under caffeine and placebo conditions, it can be said that higher lactic anaerobic power at fatigued state is likely due to the caffeine ingestion. To our knowledge no study has examined the effect of caffeine ingestion on lactic anaerobic power after a match simulation. The exact mechanism by which caffeine increases lactic anaerobic performance reserve after simulated game is not clear. This may root from caffeine stimulating effect on central nervous system which leads to damping pain perception during high intensity exercise (Davis & Green, 2009). We think that higher lactic anaerobic performance under caffeine condition is probably related to caffeine's pain damping effect with consequent of increase in glycolytic flux under fatigued condition (Davis & Green, 2009).

After simulated protocol, the maximal aerobic velocity [$V_{amax(5)}$] was significantly lower than pre protocol measure for caffeine and placebo trials(figure4). Castagna et al (2009) showed that the mean intensity level of simulated futsal play is equal to the 85- 90% of HRmax and 75% of VO_{2max}. Such intensity is an indication of a significant energy drive form aerobic pathway during simulated futsal match (Milioni,Vieira, Barbieri, Zagatto, Nordsborg, Barbieri, Dos-Santos, Santiago & Papoti, 2016). Therefore, we think that reduction of aerobic performance after simulated futsal match is probably associated with aerobic energy system taxing during simulated protocol.

Our result showed that post protocol aerobic performance was significantly higher in the caffeine trail than that of placebo (figure4). In contrast, Desbrow et al (2009) showed that administration of 1.5 or 3 mg/ kg body mass caffeine has no significant effect on time trial performance which was conducted following cycling for 120 min at 70% of VO_{2max}.

On the other hand, in a study on caffeine effects, well-trained cyclists ingested 1, 2 or 3 mg/kg caffeine before exercise test (Pallares, Fernandez-Elias, Ortega, Muñoz, Munoz-Guerra & Mora-Rodriguez, 2013). The exercise protocol was consisting of 20 min cycling at 80 % VO2max, then 15 min all out riding following a 5 minute recovery period. These authors showed that 2 and 3 mg/kg caffeine could increase 15 minutes cycling performance in the trained cyclists.

Endurance performance improvement due to caffeine ingestion has been explained by the previous studies (Desbrow, Barrett, Minahan, Grant & Leveritt, 2009), which may to some extent be true about the current study. Caffeine intake has been shown to increase SNS activation through increase in adrenaline which leads to elevated FFA appearance in the circulation (Sökmen, Armstrong, Kraemer, Casa, Dias, Judelson, & Maresh, 2008). Caffeine can also positively affect endurance performance through greater release of Ca^{+2} and improved Na^{+}/K^{+} ATPase pump activity (Mohr, Nielsen, & Bangsbo, 2011). Therefore, considering the same intensity and duration for the both simulated protocols, it can be said that higher post protocol endurance performance for caffeine trail is a reflection caffeine aerobic ergogenic effect which resulted in higher aerobic reserve following futsal simulation.

In conclusion, the results of this study showed that caffeine ingestion (3mmg/kg body mass) can boost aerobic and lactic anaerobic, and not alactic anaerobic performance following a simulated futsal protocol. But confirmation of these ergogenic effects requires the assessments of aerobic and anaerobic performance and related circulating indices during a simulated futsal match.

Conflict of interest

The authors have no conflict of interest to declare.

References

Alvarez, J. C. B., D'ottavio, S., Vera, J. G., & Castagna, C. (2009). Aerobic fitness in futsal players of different competitive level. The Journal of Strength & Conditioning Research, 23(7), 2163-2166.

Barbero-Alvarez, J., Soto, V., Barbero-Alvarez, V., & Granda-Vera, J. (2008). Match analysis and heart rate of futsal players during competition. *Journal of sports sciences, 26*(1), 63-73.

Berthon, P., Fellmann, N., Bedu, M., Beaune, B., Dabonneville, M., Coudert, J., & Chamoux, A. (1997). A 5-min running field test as a measurement of maximal aerobic velocity. *European journal of applied physiology and occupational physiology, 75*(3), 233-238.

Carpenter, T. A. (2014). *Effects of Power Output Utilizing Post-Activation Potentiation versus Static Stretching on the Vertical Jump.* The William Paterson University of New Jersey.

Castagna, C., D'Ottavio, S., Vera, J. G., & Álvarez, J. C. B. (2009). Match demands of professional Futsal: a case study. *Journal of Science and medicine in Sport, 12*(4), 490-494.

Cipryan, L., & Gajda, V. (2011). The influence of aerobic power on repeated anaerobic exercise in junior soccer players. *Journal of human kinetics, 28*, 63-71.

Dal Pupo, J., Detanico, D., Ache-Dias, J., & Santos, S. G. d. (2017). The fatigue effect of a simulated futsal match protocol on sprint performance and kinematics of the lower limbs. *Journal of sports sciences, 35*(1), 81-88.

Davis, J., & Green, J. M. (2009). Caffeine and anaerobic performance. *Sports Medicine, 39*(10), 813-832.

Desbrow, B., Barrett, C. M., Minahan, C. L., Grant, G. D., & Leveritt, M. D. (2009). Caffeine, cycling performance, and exogenous CHO oxidation: a dose-response study. *Medicine & Science in Sports & Exercise, 41*(9), 1744-1751.

Dogramaci, S. N., Watsford, M. L., & Murphy, A. J. (2011). Time-motion analysis of international and national level futsal. *The Journal of Strength & Conditioning Research, 25*(3), 646-651.

Doherty, M., Smith, P. M., Hughes, M. G., & Davison, R. R. (2004). Caffeine lowers perceptual response and increases power output during high-intensity cycling. *Journal of sports sciences, 22*(7), 637-643.

Gioldasis, A. (2016). A Review of Anthropometrical, Physiological, Psychological and Training Parameters of Futsal. 4(3), 240-259.

Harmanci H, Kalkavan A, Karavelioglu MB, Sentürk A(2013). Effects of creatine supplementation on motor performance in female futsal players. *The Online Journal of Recreation and Sport*, 2(4): 14-20.

Karavelioglu, M. B. (2014). Detection of the effects of sodium bicarbonate supplement on blood lactate and heart rate values of female futsal players before and after Yo-Yo/1 test. *Anthropologist*, *18*(3), 745-749.

Leite, W. S. (2016). PHYSIOLOGICAL DEMANDS IN FOOTBALL, FUTSAL AND BEACH SOCCER: A BRIEF REVIEW. *European Journal of Physical Education and Sport Science*, 2(6), 1-9

Milioni, F., Vieira, L. H., Barbieri, R. A., Zagatto, A. M., Nordsborg, N. B., Barbieri, F. A., Dos-Santos, J. W., Santiago, P. R., & Papoti, M. (2016). Futsal match-related fatigue affects running performance and neuromuscular parameters but not finishing kick speed or accuracy. *Frontiers in physiology, 7*(528), 1- 10.

Mohr, M., Nielsen, J. J., & Bangsbo, J. (2011). Caffeine intake improves intense intermittent exercise performance and reduces muscle interstitial potassium accumulation. *Journal of applied physiology, 111*(5), 1372-1379.

Pallares, J. G., Fernandez-Elias, V. E., Ortega, J. F., Muñoz, G., Munoz-Guerra, J., & Mora-Rodriguez, R. (2013). Neuromuscular responses to incremental caffeine doses: performance and side effects. *Medicine & Science in Sports & Exercise*, *45*(11), 2184-2192.

Pikosky, M. A., Gaine, P. C., Martin, W. F., Grabarz, K. C., Ferrando, A. A., Wolfe, R. R., & Rodriguez, N. R. (2006). Aerobic exercise training increases skeletal muscle protein turnover in healthy adults at rest. *The Journal of nutrition, 136*(2), 379-383.

Sökmen, B., Armstrong, L. E., Kraemer, W. J., Casa, D. J., Dias, J. C., Judelson, D. A., & Maresh, C. M. (2008). Caffeine use in sports: considerations for the athlete. *The Journal of Strength & Conditioning Research, 22*(3), 978-986.

Spriet, L. L. (2014). Exercise and sport performance with low doses of caffeine. *Sports Medicine, 44*(2), 175-184.

Tucker, M. A., Hargreaves, J. M., Clarke, J. C., Dale, D. L., & Blackwell, G. J. (2013). The effect of caffeine on maximal oxygen uptake and vertical jump performance in male basketball players. *The Journal of Strength & Conditioning Research, 27*(2), 382-387.