ORIGINAL ARTICLE

Effects of varying doses of caffeine intake on physiological responses among university hockey players in Edo State, Nigeria

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Abstract

The purpose of the study was to explore the effect of varying doses of caffeine intake on the physiological responses among university hockey players in performance. A total of sixty-four (64) hockey players consisting of 32 males and 32 females participated in the study. The hypotheses are that there would be no significant difference in the responses of different doses of caffeine intake on resting systolic blood pressure, diastolic blood pressure, heart rate, vital capacity, and Maximum Oxygen uptake of hockey players in tertiary educational institutions in Edo State. The test instrument used was an adaptation of a 3-Cone shuttle drill fitness testing exercise battery as developed by Koen, Honkemper, and Pietrispens (2001). A quasi-Experimental research design was used for the study. Hockey players in the three experimental groups made up of 16 players (8 males and 8 females) each were subjected to the ingestion of three (3) separate doses of 260mg, 520mg, and 780mg respectively of strong black unsweetened coffee in cups, one hour before testing. The control group of 16 players (8 males and 8 females) was not exposed to the ingestion of coffee but the ingestion of locally prepared "zobo" drink. Descriptive statistics of mean, range, and standard deviation as well as One-Way Analyses of Variance (ANOVA) were respectively used to descriptively analyze the data and test the hypotheses at a 0.05 significant level. The results showed that there were statistically significant differences in the players' responses to caffeine intake on the resting systolic blood pressure, resting diastolic blood pressure, resting heart rate, and Maximum Oxygen Consumption (VO_2max) among the hockey players. No significant difference was recorded in the responses to caffeine intake on the vital capacity of the hockey players. Specifically, although each of the three various doses (260mg, 520mg, and 780mg) was able to effect significant physiological positive changes, a dose of 260mg was spotted as the best dosage for effective physiological improvements in hockey performance.

Keywords Caffeine • Hockey players • Physiological responses.

Introduction

Hockey is a team sport with heavy demands on the player's physiology. Hockey players require high aerobic and anaerobic power, good agility, joint flexibility, and muscular development, and are capable of generating high rotational force during fast movements (Bishop, 2010). For hockey players to be able to perform effectively and efficiently as well as show skill mastery competence, such players require good skill training, physiological conditioning as well a proper psychological profile. It is through well-planned, structured scientific training and conditioning that hockey player achieve such high level of physiological readiness and adaptation.

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However, successful performance in ball games stresses not only the physiological systems but also imposes a high degree of technical and cognitive demands (McDaniel, McIntire, Streitz, Jackson & Gaudet, 2010).

It has been observed by (Agwubike, 2005; Glynn & Fiddle, 2009) that certain physiological changes accompany sports performance. These changes include, among others, increase and enhanced blood pressure, heart rate, respiration, oxygen- uptake, blood circulation velocity, and force of muscular contraction. According to The Mayo Clinic (2007), normal systolic blood pressure for adults is less than 120 mmHg and systolic levels over 140 mmHg are considered high. The Mayo Clinic (2007), further emphasized that these numbers can be chronically elevated, a condition known as hypertension, and alternatively, systolic blood pressure may rise temporarily due to stress, activity, or drugs, such as caffeine. They further pointed out that the amount of caffeine in 2 to 3 cups of coffee can cause systolic blood pressure to rise between 3 and 14 mmHg and diastolic pressure can be increased from 4 to 13 mmHg. This is typically a temporary rise in blood pressure levels, and its effects are short-lived.

However, Systolic blood pressure raises in a positive linear pattern with an increase in the amount of caffeine administered (Robert, 2005; Farag, Whitsett, Mckey, Wilson, Vincent, Everson-Rose, & Lovallo, 2010). The jump in blood pressure could be related to caffeine's effects on the blood vessels or the fact that caffeine causes the body to secrete more adrenaline, which in turn makes the blood pressure rise (The Mayo Clinic, 2007). Molt, O'Cannor, and Dishman (2003) and Molt, O'Cannor, Tubandt, Puetz, and Ely (2006) emphasized that caffeine will continue to affect the body as long as it remains in the blood. Caffeine was reported to increase blood pressure 70 years ago (Myer, 2004). According to Lichtenstein (2002), caffeine could block a hormone that helps keep the arteries widened. To her, caffeine causes the adrenal gland to release more adrenaline which causes the blood pressure to increase. Some people who regularly drink caffeine have a higher average blood pressure than those who drink none (Lichtenstein, 2002).

Consumption of a large amount of caffeine leads to heart palpations (Lancu, Olmer & Strous, 2007). The same authors classified caffeine as a stimulant because when consumed in even small amounts, it will stimulate the central nervous system, the cardiac muscle (causing an increased heart rate, and blood pressure), and the respiratory system. As a CNS stimulant, caffeine triggers and increases blood circulation, heart rate, urine output, and gastric secretion and causes a decrease in glucose metabolism (Armstrong, 2002). Weinberg and Bealer (2002) confirmed that caffeine acts at other sites in the body to increase heart rate, constrict blood vessels, relax air passages to improve breathing, and allow some muscles to contract more easily. Molt et al (2003) and Molt et al (2006) further explained that caffeine doses ranging from 250mg to 750mg can produce an abnormal restlessness, rapid heart rate, abnormal heart rhythms, higher blood pressure, birth defects in offspring, higher body temperature and increased secretion of gastric acids leading to a stomach problem. Others are nausea, headache, tense muscles, and sleep disturbances and can also cause Anorexia. They pointed out also that doses over 750mg can produce a reaction similar to an anxiety attack including delirium, ringing ears, and light flashes. It was stated that this amount of caffeine may come from a single dose or from many doses in a short time. Penagiotakos (2003), stated that caffeine increases the risk for heart diseases when a person becomes classified as a "heavy drinker". It was also confirmed by Grobbee, Rimm, Giovannucci, Colditz, Stampfer, Willet, (1990) and Griffith (2008) that high doses of caffeine can negatively affect concentration, attention, and behavior and can produce irregular heartbeat, nausea, restlessness, heartache, and dehydration. George, Light, Matthay, and Matthay, (2005) confirmed that caffeine stimulates the central nervous system and therefore increases the heart rate.

Griffith (2008) confirmed that caffeine's short-term effects occur very quickly and last about four hours. These may include balance problems, a racing heart, insomnia, fatigue, and a sense of anxiety with the severity of symptoms related to the type of beverage and quantity consumed. He further stated that over time, as little as one cup of coffee per day is likely to raise blood cholesterol and blood pressure and cause the heart to race or have extra beats and one to five cups of coffee a day increases the risk of heart attack by 60 percent over those who have none, and six or more cups a day increases the risk by 120 percent. Coffee, whether caffeinated or decaffeinated, has been linked to an increase in blood pressure in people who drink more than 2 cups a day regularly (Olbrantz & Peterson, 2007).

Although the effects of caffeine have been debated, research suggests that caffeine normally results in an increase in blood pressure and perceived attention (Olbrantz & Peterson, 2007). The increase in heart rate from caffeine consumption can take effect in as soon as 15 minutes and can take approximately six hours to wear off (Rist, 2010). Caffeine is not stored in the body but is eventually excreted when a person urinates. According to the University of Michigan, although sensitivity to caffeine varies from person to person, caffeine can increase heart rate by approximately three beats per minute (Rist, 2010).

Vital capacity is the maximum air a person can exhale from the lungs after maximum inhalation. Caffeine increases peak flow, vital capacity, and diastolic blood pressure (George et al, 2005). Caffeine also works through several mechanisms and has weak diuretic effects and these effects depend on the individual. The weak effects decrease diastolic blood pressure but vasoconstriction increases it. Leonard, Watson, and Mohs (1987), Graham (1991); Sokman, Armstrong, Kreamer, Casa, Daas, Judelson, and Maresh (2008) in their contributions stated that caffeine has other global effects on hormonal, muscular, cardiovascular, pulmonary and renal functions during exercise. They went further to report that research studies on the effect of caffeine in humans confirm that caffeine is a bronchodilator. It improves pulmonary function, and although it is a weak bronchodilator, it clearly has beneficial effects on direct measurements of lung function, such as the vital capacity, and also stimulates bronchodilator of alveoli, vasodilatation of blood vessels, neural activation of muscular contraction, and blood filtration in the kidneys as well as stimulates the heart, respiratory system, and central nervous system. Extreme overdose can result in death (Sokman, et al, 2008).

Maximum Oxygen uptake (VO_2max) is considered the standard to measure the physiological intensity of exercise. Maximum Oxygen Uptake (VO_2max) or consumption is the maximum rate at which oxygen can be taken up, distributed, and used by the body in the performance of work (Bassert & Howley, 2000). Thus, maximum oxygen uptake (VO_2max) has been used in recent research which aims at elucidating the mechanism of caffeine during maximal efforts (Bahia, Fernandez de Aguiar, Lopez, Barreto, Siqueira Gualberto, et al, 2006). Bahia et al (2006) also emphasized that caffeine has frequently been used acutely, previously for physical exercise, to delay fatigue and consequently improve performance, especially in endurance activities such as hockey. It was further stressed that 5% of caffeine consumers who abstained from caffeine for 12 to 24 hours presented at least one of the four main symptoms: headache, fatigue, dysphoria (depression or a feeling of emotional and mental discomfort), lethargy, bad temper, irritation, depression, the difficulty of concentration, and 13% felt sick.

The question that may agitate one's mind is "what is the possible response of caffeine intake to the physiological variables of hockey players? This informed why this study is not only necessary but also imperative.

The following hypotheses were formulated and tested.

1) There would be no significant difference in the responses of different doses of caffeine intake on resting systolic blood pressure of hockey players in tertiary educational institutions in Edo State.
2) There would be no significant difference in the responses of different doses of caffeine intake on resting diastolic blood pressure of hockey players in tertiary educational institutions in Edo State.
3) There would be no significant difference in the responses of different doses of caffeine intake to the resting heart rate of hockey players in tertiary educational institutions in Edo State.
4) There would be no significant difference in the responses of different doses of caffeine intake on the vital capacity of hockey players in tertiary educational institutions in Edo State.
5) There would be no significant difference in the effect of varying doses of caffeine intake on VO_2max of hockey players in tertiary educational institutions in Edo State?

Method

Participants

The population for the study was all registered hockey players (school team) made up of both the regular and the reserve players from the University of Benin, Benin City, and Ambrose Ali University, Ekpoma which had outstanding hockey teams among the six tertiary educational institutions (Universities) in Edo State.

Measuring instrument

The test instrument used in this study was an adaptation of the protocol of Archna and Jasper (2008). The adaptation involved giving each of the three experimental groups doses of 260mg, 520mg, and 780mg respectively. The control group was given 260mg of "zobo" drink. To ascertain the effect of the doses of caffeine on the sports performances of the hockey players, a 3-Cone Shuttle Drill Test developed by Koen, HonKemper, and PietRispen (2001) was validated and used. Blood pressure was measured with KRIS-ALOY, KA-112 Aneroid Sphygmomanometer, and Stethoscope (Medicare Instrument WUXI LTD, Wuxi, Jiangsu China). $V0_2max$ was measured using the Cooper VO_2max test. Heart rate was measured with a Heart monitor (Lloydspharmacy Heart Rate Monitor and Chest Transmitter, K901B. 2003, UK) and Vital capacity was measured with a portable hand-held Spirometer (Voldyne, Sherwood Medicals, St. Louis, MO, USA).

Procedure

The sample for the study was 64 players (32 males and 32 females) from two randomly selected Nigerian Universities. Participants were recruited from the regular team players and their reserved players. A purposive sampling technique was used for the study. Sample selection was achieved through a multi-stage approach. Informed consent forms were given to the players to complete and their rate of consumption of caffeine before this time was assessed. Only individuals with minimal caffeine consumption were included in the study.

Research design

The pre-posttest control group experimental research design was adopted to investigate the effect of caffeine (coffee) in enhancing sports performance among hockey players. This design was chosen since it has to do with the cause-and-effect relationship of performance differences amongst athletes.

Data analysis

The data were analyzed using descriptive statistics of mean, range, and standard deviation. They were used to answer the research questions raised by analyzing changes in physiological parameters and performance (work) alterations at the control and after ingesting varying caffeine dosages.

Results

In Table 1, the Analysis of Variance (ANOVA) was used to determine the responses of different groups to the varying doses of caffeine intake on the resting systolic blood pressure of hockey players and other variables. The F value of 37.758 was significant at 0.05 level with 3 and 60 degrees of freedom. Thus, the null hypothesis which stated that there is no significant difference in the responses of different groups to varying doses of caffeine intake on resting systolic blood pressure was rejected. This implies that there are significant differences in the responses of different groups to varying doses of caffeine intake on the resting systolic blood pressure of hockey players.

Table 1. Differences between different supplemented groups of hockey players

	260mg caffeine (n = 16)	520mg caffeine (n = 16)	780mg caffeine (n = 16)	Control group (n = 16)		
Variable	M±SD	M±SD	M±SD	M±SD	F	p
Resting systolic blood pressure (mmHg)	145.63±9.64	137.81±6.57	150.62±8.54	122.50±6.83	37.758	<0.001
Resting diastolic blood pressure (mmHg)	82.50±4.47	88.13±8.34	93.75±5.00	79.38±2.50	21.310	<0.001
Resting heart rate (n/min)	185.94±5.16	188.19±4.15	199.88±8.55	174.94±3.36	52.209	<0.001
Vital capacity (l)	2.70±0.43	2.72±0.80	2.71±0.47	2.23±0.65	2.529	0.066
VO_2max	150.88±4.40	153.13±3.20	163.69±6.17	142.06±3.47	63.449	<0.001

Results show that the variables are significant with an F value of 21.310 at a 0.05 level. That is, there were significant differences in the responses of the three groups to varying doses of caffeine intake on the resting diastolic blood pressure of hockey players.

Also, show that the Analysis of Variance (ANOVA) applied to determine the responses of the groups to the varying doses of caffeine intake on the resting heart rate of hockey players yielded an F value of 52.209 at 0.05 alpha level with 3 and 60 degrees of freedom. Consequently, the hypothesis that claimed that there is no significant difference in the responses of the groups to the varying doses of caffeine intake by hockey players was rejected. The implication is that there are significant differences in the responses of the different groups to the varying doses of caffeine intake on the resting heart rate of hockey players.

Responses of the different groups to varying doses of caffeine intake on the vital capacity for the three experimental groups and one control group were not significant. The null hypothesis which stated that there is no significant difference in the responses of the groups to varying doses of caffeine intake on the vital capacity of the hockey players was retained. In conclusion, the responses of a different group to varying doses of caffeine intake on vital capacity did not differ among the groups.

Also, that the responses of different groups to varying doses of caffeine intake on the VO_2max of hockey players were significant (F=63.449) at a 0.05 level. Therefore, the null hypothesis was rejected. The implication is differences in the responses to the varying doses of caffeine intake on the VO_2max of the three experimental groups were significant (F=63.449, sig.000) and when the control group was added to the three experimental groups and computed, it was still yielded a significant result (F=63.449, sig.000).

Discussion

The resting systolic blood pressure for each of the groups after the ingestion of caffeine (coffee) in between pre and post-test periods was assessed. In all cases, the resting systolic and diastolic blood pressures assessed with the testing protocols were statistically significant at a 0.05 level. This result aligns with those reported by Lichtenstein (2002) and The Mayo Clinic (2007) which stated that systolic blood pressure may rise due to drugs such as caffeine and that the amount of caffeine in 2 to 3 cups of coffee can cause systolic blood pressure to rise between 3 and 14mmHg. However, diastolic blood pressure can be increased from 4 to 13 mmHg. Robert (2005) further emphasized that systolic blood pressure raises in a particular linear pattern with an increase in the amount of caffeine administered. It is on this note that Lichetenstein (2002) pointed out that caffeine causes the adrenal gland to release more adrenaline which causes the blood pressure to increase. This was also supported by Myer (2004) who emphasized that caffeine was reported to have increased blood pressure 70 years ago. Molt, O'Cannor, and Dishman (2003) and Molt, O'Cannor, Tubandt, Puetz, and Ely (2006) emphasized that caffeine will continue to affect the body as long as it remains in the blood. Caffeine has the potential to affect all systems of the body as it is absorbed by most tissues.

For each group, the mean resting heart rate was recorded in this study following responses to different doses of caffeine intake. The analysis of variance conducted on the test scores for experimental groups resulted in statistically significant differences. This implies that there was a significant effect of the various doses of caffeine on the players' resting heart rate. Hence, the null hypothesis was rejected. This result agrees with the views of Molt et al (2003) and Molt et al (2006) who indicated that caffeine doses ranging from 250mg to 750mg can produce an abnormal restlessness, rapid heart rate, abnormal heart rhythms, higher blood pressure, birth defects in offspring, higher body temperature and increased secretion of gastric acids leading to a stomach problem. Others are nausea, headache, tense muscles, and sleep disturbances and can also cause Anorexia. They pointed out also that doses over 750mg can produce a reaction similar to an anxiety attack including delirium, ringing ears, and light flashes. It was stated that this amount of caffeine may come from a single dose or from many doses in a short time. This position is further supported by Penagiotakos (2003) who stated that caffeine increases the risk for heart diseases when a person becomes classified as a "heavy drinker". In his support, Griffith (2008) also confirmed that high doses of caffeine can negatively produce irregular heartbeat and also leads to a racing heart. Rist (2010) pointed out that an increase in heartbeat following ingestion of caffeine can take effect within 15 minutes and can take approximately six hours to wear off. Rist (2010) has also indicated that caffeine can increase heart rate by approximately three beats per minute. One may assert that the effect of caffeine on heart rate is expected since caffeine is a central nervous system stimulant, hence the rapidity of the effect. This, therefore, was in support of Zaratsky (2011) who confirmed that caffeine elevates heart rate and gives people a boost of energy. According to Zaratsky (2011), caffeine consumption may have a moderately beneficial effect on short-term weight loss depending on how the drug affects the individual.

The result of the analysis of variance in respect of vital capacity led to the acceptance of the null hypothesis since there was no significant difference in the responses of the players to the varying doses of caffeine intake. This was confirmed by Wilcox (1985) who indicated that individuals vary in their responses due to subtle differences in physiology and body chemistry. He further added that chronologically, ingesting caffeine before exercise in an aerobic training program may enhance the fat-reducing effects of exercise. In their opinion, George et al (2005) have stated that caffeine works through several mechanisms, and has weak diuretic effects and these effects depend on the individual. The present result is, however, at variance with the contention of Iyawe, Igweh, Orie, and Umapathy (1999) and Sokman et al (2008) who reported that caffeine ingestion stimulates bronchodilator of alveoli as well as the respiratory system.

The result of the analysis of variance led to the rejection of the null hypothesis concerning VO_2max. The result implies that there was a significant difference in the responses of the different groups to varying doses of caffeine intake on VO_2max of hockey players. This shows that the caffeine the players ingested increased the amount of their oxygen consumption during exercise. This is in line with Bahia et al (2006) submission that caffeine has frequently been used acutely, previously for physical exercise, intending to delay fatigue and consequently improve performance, especially in endurance activities such as hockey playing. Palusca (2003) and Jensen (2009) have revealed that caffeine improves athletes' endurance in sports where long-term stamina is needed; it plays physical as well as psychological roles in the performance of an athlete. Graham (2001) in his contribution said that caffeine ingestion improves performance during short-term exercise lasting approximately 5minutes at 90 to 100 percent of maximum oxygen uptake in the laboratory.

Conclusion

The results of this study showed that there were statistically significant differences in the player's responses to caffeine intake on the resting systolic blood pressure, resting diastolic blood pressure, resting heart rate, and maximum oxygen consumption (VO_2max) among hockey players. No significant difference was recorded in the response to caffeine intake on the vital capacity of the hockey players. These observed differences were not recorded for the control group regarding their physiological responses.

The results of the present study have proved that caffeine ingestion could favorably and significantly alter the physiological variables of hockey players within one hour of intake. Since the results of the control group did not show favorable alterations, it implies that caffeine (coffee) ingestion caused these favorable alterations (results) for the experimental groups. Based on the results of the present study where four (4) out of the five (5) hypotheses were rejected, it follows that those physiological variables that were altered outweighed those not altered or improved upon. Specifically, although each of the three various doses (260mg,520mg, and 780mg) was able to effect significant physiological positive changes, a dose of 260mg was spotted as the best dosage for effective physiological improvements in hockey performance.

Recommendations

Based on the findings of this study, the following recommendations were made:

1) Although, the ingestion of certain doses of caffeine is efficacious; there is a need for players to avoid short-cut approaches to enhance performance, rather they should train and work hard by considering a well-balanced and varied diet daily to support their scientific training efforts to earn success in sports engagements.
2) Coaches/trainers should lead their players to be aware of the physiological implications of the use of caffeine as an ergogenic aid in sports.

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