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An exploration of the correlation between stress and blood glucose levels in athletes: Strategies for maintaining peak performance

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ABSTRACT

Background Problems: Stress can cause a person to experience an accumulated risk of increased cholesterol and negatively impact performance in the field, as indicated by a decrease in blood glucose levels. **Research Objectives**: This research aims to identify the relationship between stress and blood glucose levels to find solutions for athletes to maintain glucose levels when competing. **Methods**: The research method was cross-sectional with an observational study approach. Glucose levels were assessed using an Accu-Chek device, while anxiety levels were assessed using the Perceived Stress Scale (PSS) questionnaire. The research subjects were 130 Provincial Training Camp (PELATPROV) athletes with an average age of 25.01 ± 5.15 years old, a weight of 64.15 ± 7.93 kg, a height of 171.21 ± 5.88 cm, and a BMI of 21.98 ± 3.71 kg/m^2. **Findings and Results**: The results indicated significant differences in stress (0.001 < 0.05) and blood glucose levels (0.001 < 0.05) between the two groups. The pre-PON athlete group dominated the increase in stress and decrease in blood glucose levels compared to the non-Pre-PON group. Thus, this research has provided evidence of a correlation between stress levels and decreased blood glucose levels. **Conclusion**: Psychological and physiological aspects were proven to have an inevitable correlation. Athletes and coaches must communicate more deeply about the expected treatment during the preparation period, during and after the match, to understand each other's needs to achieve performance. Therefore, athletes' performance can be maintained well during competition and training.

Keywords: Stress; blood glucose; performance; athletes

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INTRODUCTION

Jambi Province's achievement in sports at the prestigious national event, i.e., National Sports Week (PON), was the forerunner to the rise of sports achievements in Jambi Province. By winning six gold medals, ten silver medals, and 13 bronze medals, Jambi can finish in 18th place or five places up from the 2016 West Java PON, previously ranked 23rd (Sidik, 2021). Generally, sporting achievements greatly impact a region (city, district, or country). They are a matter of pride or prestige; thus, it is respected by other regions, political recognition,

and even an economic sector (Kavaliauskaitė, 2015). However, current progress in sports performance will not happen without supporting factors like monitoring athlete physiology, nutrition, and athlete psychology.

Stress is a multidimensional and universal phenomenon that is usually oriented towards a process of achieving success or a person's adaptation process (Birditt et al., 2016). Stress that occurs in individuals is a common thing, e.g., among students, it can be caused by various stressors such as environmental changes, economic problems, academic problems, prospects, friendships, and social problems (Huberty et al., 2019; Kim, 2014; Yeom & Choi, 2013). Meanwhile, the stress that athletes often experience is commonly caused by pressure before the match, such as high training loads, irregular training schedules, changing eating patterns, family problems, partners, and the name of the region or country (Berriel et al., 2020). On the other side, if this stressor is not managed well, it can have a negative effect on the athlete's physical and psychological health (Gibbons et al., 2011; Huberty et al., 2019). In addition, this problem can also cause a decrease in physical abilities in athletes. Hence, as an initiation, it is necessary to carry out various activities and behavioral patterns to prevent and reduce the potential risk of experiencing stress (Lee & Kim, 2019; Ratanasiripong et al., 2012; Yeom & Choi, 2013).

Stress or depression in athletes before a match can interfere with performance during the match (Berriel et al., 2020; Ranjbar et al., 2015). When an athlete experiences stress, it indicates greater energy expenditure due to fear and excessive body response (Fortes et al., 2018). Thus, it potentially reduces the content of energy sources in the blood, even though it can support performance on the field for energy production (Trzmiel et al., 2021). One source of energy, i.e., glucose in the blood and muscles, which is distributed in the cardiovascular system, fulfills energy needs after physical work (Sylow et al., 2017). The ability to manage stress or anxiety in athletes can be one of the keys to achieving the highest performance (Lee & Kim, 2019).

Stress can cause a person to experience an accumulated risk of increased cholesterol (Amiruddin et al., 2019) and trigger a negative effect on performance in the field (Berriel et al., 2020). Not only players but referees also experience a decrease in their ability to make decisions quickly (Mirjamali et al., 2012; Santos et al., 2017). Stress levels are also related to glucose levels (Rafiei et al., 2023). Fulfillment of psychological aspects needs special attention when applied to athletes. Indeed, several methods have been found to help cure or reduce stress or depression experienced by athletes, especially the burden before the competition. In practice in the world of sports, especially when working with athletes, the methods used stop at the imagery training aspect only (Abiş et al., 2021; Elsegood & Wongpakaran, 2012; Fekih et al., 2021; Lin et al., 2021). This method is easier to be applied in the field than yoga practice interventions before or after practice.

Hopefully, the relationship between stress and glucose levels can be identified, and a solution can be found; thus, when approaching the competition, athletes do not experience excessive stress and have sufficient glucose levels. The urgency to identify stress conditions in athletes needs to be implemented immediately so that the adverse effects of decreasing glucose levels in athletes can be treated immediately. It is due to preparations for matches at the pre-PON level, which aims to prepare for a more prestigious level of competition, i.e., PON. Heretofore, literature studies only provided information regarding the relationship between stress and glucose, but only in certain groups of individuals, such as diabetes sufferers (Rafiei et al., 2023). Other research also revealed the effects of stress on cholesterol and triglycerides (Amiruddin et al., 2019). Meanwhile, not much has been studied about the effects of stress on glucose in athlete groups; thus, this research must be carried out immediately.

Expediently, this deepening of the stress topic will help coaching staff and administrators in choosing the right treatment with the individualization principle. The research results are expected to be capable of mapping the condition of stress and glucose level on athletes in the Sumatra Island area, especially Jambi. Additionally, it would greatly impact coaches in treating their athletes with the various psychological conditions of each athlete. This research was a first step in exploring deficiencies in stress management in athletes; hopefully, it will not significantly interfere with glucose storage in the blood. The objective of this study is to investigate the link between glucose levels and depression levels in athletes, with a focus on how these factors interact and mutually impact each other. Therefore, it will be known about the problem of whether glucose levels (in this case, it will be integrated with eating habits and daily activity behavior) will be able to interact with the individual's level of depression in term of load to exhibit peak performance.

METHOD

This research employed a cross-sectional method with an observational study approach. This method was used to collect data at a certain time without any intervention to find a correlation between athletes' stress levels and blood glucose levels in the two groups. The total research subjects were 130 Jambi Provincial Training Camp (Pelatprov) athletes consisting of 65 Pre-PON athletes and 65 non-Pre-PON athletes. All subjects were collected based on the inclusion criteria: being in good health, not consuming alcohol, not under the influence of drugs, and actively exercising for an average of 10 hours per week. The data collection process was carried out one day before the Pre-PON competition, and blood samples were taken in the morning between 07.00 – 09.00 a.m with normal room temperature ranging from 25-27^{o}C.

The parameters measured in this research were age, weight, height, BMI, stress level, and blood glucose. Before data collection was carried out, researchers instructed participants to fast for at least 8 hours before taking a blood test. It was done to minimize bias in the data. The average age of the subjects in the research ranged from 25.01 ± 5.15 years, weight 64.15 ± 7.93 kg, height 171.21 ± 5.88 cm, and BMI 21.98 ± 3.71 kg/m^2.

Measurements and Research Procedures

Anthropometry

Age data was collected using a questionnaire distributed to subjects during the test. Then, body height was measured using a GEA brand manual stature meter, carried out directly by the researchers. Body weight measurements were obtained using SECA 762 brand scales. Meanwhile, BMI was measured using metric units by dividing body weight (kilograms) by body height squared (meters) (Santos et al., 2014).

Blood Glucose

Blood glucose checks were carried out using the *Accu-Chek Guide* tool. Blood glucose measurements were attained by taking a blood sample from the subject's fingertip with a test strip and immediately analyzing it using the Accu-Chek Guide tool. All subjects were required to fast for 8 hours except mineral water before taking blood samples. The glucose test method that researchers used was fasting blood glucose, with the criteria as you can seen on the Table 1.

Table 1. Classification of Fasting Blood Glucose

Blood Glucose Classification	Fasting Blood Glucose Levels
Low	< 70mg/dL
Normal	≤ 70 – 100 mg/dL
Prediabetes	100 – 125 mg/dL
Diabetes	> 126 mg/dL

(Mohamed, 2019)

Stress Level

Data collection on athletes' stress levels was measured using the Perceived Stress Scale (PSS) questionnaire. This questionnaire has been developed since 1983 and was recommended as a proper questionnaire to help someone understand how the situation affects their feelings and stress (Son et al., 2020). Individual scores on the PSS could range from 0 to 40, with higher scores indicating higher perceived stress. The scores 0-13 would be considered low stress. Then, the scores 14-26 would be considered moderate stress, and the scores 27-40 would be considered high stress (Table 2). Questions on this scale asked about your feelings and thoughts over the past month. In each case, you would be asked to indicate how often you feel or think a certain way. Each answer would be scored on a scale of 1 to 4. Although some questions were similar, they were different, and you should treat each question as separate. The best approach was to answer fairly quickly. The stress level index was calculated by adding up all the scores obtained from 10 questions (Table 3)., but for questions 4, 5, 7, and 8, the scores were changed to 0=4, 1=3, 2=2, 3=1, 4=0.

Table 2. Classification of Stress Levels

Stress Level Classification	Score
Low	0-13 points
Moderate	14-26 points
High	27-40 points

Table 3. Perceived Stress Scale Questionnaires

No	PSS Items	Scale (1-4)
	0 – never 1 - almost never 2 - sometimes 3 - fairly often 4 – very often	
1	How often have you been upset about something unexpected that occurred in the last month?	4
2	How often have you noticed in the last month that you could not control essential things in your life?	4
3	How often have you felt nervous and stressed in the last month?	4
4	How often have you perceived self-confidence to handle your problems in the last month?	4
5	How often have you felt that things were happening as you expected in the last month?	4
6	How often have you realized in the last month that you could not accomplish the things that you had to do?	4
7	How often have you been able to control irritability in your life in the last month?	4
8	How often have you perceived that you were on top of things in the last month?	4
9	How often have you been angered because of uncontrollable problems in the last month?	4
10	How often have you experienced high-accumulated difficulties that you could not overcome in the last month?	4
	Total Score of PSS	**40**

Data Analysis

The research data are in the form of mean and standard deviation. To compare the two groups, anthropometric data such as age, weight, height, and BMI were tested using one-way analysis or one-way ANOVA. In addition, the stress level questionnaire and blood glucose samples were analyzed using an independent sample t-test paired t-test to test the differences between the two groups. All statistical analyses used the SPSS version 22 application with a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

The research results indicated that the average age, weight, height, and BMI in the two groups, both Pre-PON athletes and non-Pre-PON athletes, did not show any statistically significant differences (see Table 4).

Table 4. Anthropometric Data for Both Groups

Variable	Total (N=130)	Group		p-value
		Pre-PON (n=65)	Non-Pre-PON (n=65)	
Age (years)	25.01 ± 5.15	24.32 ± 4.84	25.71 ± 5.82	0.129
Weight (kg)	64.15 ± 7.93	64.57 ± 8.73	63.74 ± 7.13	0.107
Height (cm)	171.21 ± 5.88	171.81 ± 5.32	170.62 ± 6.45	0.312
BMI (kg/m2)	21.98 ± 3.71	21.92 ± 3.21	22.05 ± 4.21	0.098

*significant average difference $p < 0.05$

Table 5. Data on Stress Levels and Glucose Levels for Both Groups

Variable	Total (N=130)	Group		*p*-value
		Pre-PON (n=65)	Non-Pre-PON (n=65)	
PSS (score)	26.07 ± 7.92	28.72 ± 9.13	23.42 ± 6.72	0.001*
Blood Glucose (mg/dL)	91.77 ± 4.43	82.67 ± 4.21	100.87 ± 4.65	0.001*

*significant average difference $p < 0.05$

Table 5 revealed that there were significant differences between the two groups. The score on the stress variable was 28.72 points for the Pre-PON athlete group, while for non-Pre-PON athletes, it was 23.42 points. It can be implied that the pre-PON group had a high level of stress when compared to the non-pre-PON group. Furthermore, there was also a significant difference in blood glucose levels. Even though both groups had normal blood glucose levels, Pre-PON athletes had lower glucose levels of 82.67 mg/dL compared to the non-pre-PON group at 100.87 mg/dL

Table 6. Percentage of Stress Level Classification between the Two Groups

No	Classification for Stress Level	Pre-PON (n=65)	Percentage (%)	Non-Pre-PON (n=65)	Percentage (%)
1	Low (0-13 points)	12	18	30	46.1
2	Moderate (14-26 points)	20	30.7	24	36.9
3	High (27-40 points)	33	50.7	11	16.9

Table 7. Percentage of Blood Glucose Between the Two Groups

No	Classification for Blood Glucose	Pre-PON (n=65)	Percentage (%)	Non-Pre-PON (n=65)	Percentage (%)
1	Low (< 70mg/dL)	23	35.3	13	20
2	Normal (≤ 70 – 100 mg/dL)	36	55.4	43	66.2
3	Prediabetes (100 – 125 mg/dL)	6	9.3	9	13.8
4	Diabetes (> 126 mg/dL)	-	-	-	-

Table 6 indicated that the percentage of stress levels in the pre-PON athlete group was in the high category at 50.7%, while non-pre-PON athletes were only 16.9%. Likewise, with the blood glucose percentage, the pre-PON athlete group, which was included in the normal category, was 55.4%, while the non-pre-PON group was greater, namely 66.2%. Low blood glucose levels were also greater in the pre-PON athlete group than in non-pre-PON athletes (see Table 7).

The results showed significant differences in Pre-PON and non-Pre-PON athletes' stress and blood glucose levels. Pre-PON athletes' stress levels were higher than the non-Pre-PON group, while blood glucose levels in non-Pre-PON athletes were higher than in Jambi Pre-PON athletes. It implied that athletes had a psychological burden to always perform well on the field without exception because the target was to get maximum performance. It differed from the non-group, which had a lower stress level because they were not forced to complete certain targets. Furthermore, it was in line with previous research, which stated that psychological burden was reflected in each individual's target size and the density of the program (Gulliver et al., 2012). The higher the volume or intensity, the greater the athlete's effort. The greater the effort exerted during a performance on the field, the greater the demands placed on each athlete (Roy, 2015). Indeed, it correlated with increased metabolic waste (Zagatto et al., 2016) and decreased blood glucose levels (Cartee, 2015) due to the repetition of movements.

In short, during exercise, the metabolism in the body adapts quickly. Blood glucose levels will be replenished many times faster. The anabolism phase occurs in the breakdown of glucose into pyruvate until it is converted into acetyl Co-A to enter the Krebs cycle (Jelstad et al., 2021). Then, it ends with the electron transfer phase in the aerobic cycle to produce adenosine triphosphate (ATP) (Jeukendrup, 2011; Kreider et al., 2017; Potgieter, 2013), which is employed as a basic ingredient for energy production in the body. Previous research emphasized that in sports where endurance was dominant, athletes would experience an increase in plasma insulin (Takahashi et al., 2021). In other words, when plasma insulin increases, glucose absorption automatically accelerates, which will impact reducing the amount of glucose in the blood because it is used as fuel during muscle contractions (Jelstad et al., 2021). Therefore, the results aligned with previous research, both in considering basic theory and training and biochemical theory, which continues to develop periodically. Likewise, the impact on glucose content decreased due to repetitive movements on athletes who performed repeated high-intensity activities (Sylow et al., 2017). Their blood glucose would also run out quickly if not properly prepared before training or match (Pearson et al., 2023). If they were careless, their energy would quickly be used up and unable to support their body's tough performance.

In terms of the mental health perspective, research thirty years ago stated that physical activity affected a person's mental well-being (Cherubal et al., 2019). If the intensity level were reasonable, in this case, moderate intensity, then the effect would have a good impact on the body, according to the literature review and recommendations (World Health Organization, 2020). There was much literature that supported that the most effective in maintaining health and psychological levels was moderate intensity because the dose was not too heavy for those with low fitness but also not too easy to carry out movements for those who were physically elite (Trzmiel et al., 2021). The research problem occurred when selecting inclusion criteria for Pre-PON and

non-athletes. In this case, athletes experienced pressure. High targets, intensity, and volume of training that have been set by the coaching team, as well as repetition of boring daily routines, became determining factors in the emergence of mental health disorders in athletes if they never received education from a psychologist (Firth et al., 2016; Gulliver et al., 2012). The risk of experiencing depression would also appear in athletes in individual numbers. Athletes who compete in individual numbers should have the type of coach who cares and a sports science team behind the scenes who is always ready to help. If it was not handled well, athletes sometimes had no place to talk about what they were experiencing and feeling. Depression levels would peak if small problems were never addressed, and over time, they would peak (Ranjbar et al., 2015; Schuch et al., 2018). Appropriate treatment, apart from athletes having to be accompanied by a psychologist, included the emergence of awareness in an individual match on how to manage emotions in each situation, meditation to help reduce stress levels before, during, and after the competition (Yeom & Choi, 2013), and providing various exercises or commonly called cross training to help reduce the high mental load on athletes (Knapen et al., 2015; Schuch et al., 2018). In addition, there were several things that athletes should be used to, such as imagery and self-hypnosis (Mukhopadhyay, 2021).

High stress levels will drain more energy than individuals who can control themselves in stressful conditions during a match (Gulliver et al., 2012). It will certainly interfere with performance and waste energy; hence, there will be no effectiveness in exerting energy during the match or due to the pressure experienced during training. High levels of stress will correlate with decreasing blood glucose levels if there is no intervention with stress management strategies for athletes (Lee & Kim, 2019), and good food and drink intake before the competition (Penggalih et al., 2019). There needs to be awareness from the athlete support team to remind them of mental aspects and the fulfillment of energy sources so that each individual can compete optimally during the competition.

CONCLUSION

The high level of stress in pre-PON athletes is influenced by the psychological and physical stress they experience daily, whether during training or matches. The higher the level of stress experienced, the more energy is drained. Stress management and the timing of food and drink intake must be the main considerations in the strategy to support high-achieving athletes. It has been proven that psychological and physiological aspects have an inevitable correlation. Athletes and coaches need to communicate more deeply about the expected treatment during the preparation period, during, and after the match to understand each other's needs for achieving optimal performance.

This research has several limitations, the most significant of which is its reliance on data from Jambi Province alone. Additionally, due to budget constraints, the only blood component that could be analysed was glucose. To provide recommendations for further study, additional mapping of potential issues associated with the characteristics of the sport is necessary. It is anticipated that future research will uncover significant information regarding the stress experienced before, during, and immediately after PON. An examination of various blood chemical indicators will come next, particularly those pertaining to hydration, energy sources, and metabolism during particular exercise. Given that it is common knowledge that stress can deplete one's energy, ultimately leading to more stress.

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CONFLICT OF INTEREST

The authors state no conflict of interest.

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