Effects of bee honey supplementation on cognitive performance, lactic acid levels, and VO2Max in athlete: a comprehensive study

Efectos de la suplementación con miel de abeja sobre el rendimiento cognitivo, los niveles de ácido láctico y el VO2Max en atletas: un estudio exhaustivo

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Abstract

Introduction: This has prompted scientists and sports trainers to conduct studies aimed at finding ways to help athlete achieve peak performance.
Objective: This study was carried out at the Riau Province Student Education and Training Center (PPLP) to ascertain the effects of bee honey supplementation during the Special Preparation Stage (SPS) on VO2Max, lactic acid levels, and cognitive function in female athletes.
Methodology: An experimental method was used and the samples were 56 female athletes from PPLP Riau Province. VO2Max was assessed using the Beep Test, Lactic Acid levels were determined with The Edge Blood Lactate Monitoring System, and the participants completed four cognitive function tasks: the Digit Symbol Substitution Test (DSST), Visualization of Rotations (VR), Choice Reaction Time Test (CRT), and Concentration Grid Test (CGT). The ANOVA test was used to examine the data (p<0.05).
Results: The findings demonstrated that athletes who took bee honey supplements experienced notable increases in VO2Max, a decrease in lactic acid levels, and improvements in cognitive function. The pretest, midtest, and posttest measures of VO2Max, lactic acid levels, and cognitive function showed significant differences between the athlete groups (p<0.05).
Discussion: The findings demonstrated that both SPS exercise and bee honey supplementation improved VO2Max, decreased lactic acid levels, and improved cognitive function in female athletes.
Conclusions: Supplementing with bee honey during the SPS improved VO2Max in female athletes, decreased lactic acid levels, and enhanced cognitive function.

Keywords

Bee honey; cognitive function; female athlete; lactic acid; VO2Max.

Resumen

Introducción: Esto ha llevado a científicos y entrenadores deportivos a realizar estudios con el objetivo de encontrar maneras de ayudar a los atletas a alcanzar su máximo rendimiento.
Objetivo: Este estudio se llevó a cabo en el Centro de Educación y Entrenamiento Estudiantil de la Provincia de Riau (PPLP) para determinar los efectos de la suplementación con miel de abeja durante la Etapa de Preparación Especial (SPS) en el VO2Max, los niveles de ácido láctico y la función cognitiva en atletas femeninas.
Metodología: Se utilizó un método experimental y las muestras fueron 56 atletas femeninas de la Provincia de PPLP Riau. El VO2Max se evaluó utilizando la Prueba de Beep, los niveles de Ácido Láctico se determinaron con el Sistema de Monitoreo de Lactato Sanguíneo The Edge, y los participantes completaron cuatro tareas de función cognitiva: la Prueba de Sustitución de Símbolos de Dígitos (DSST), Visualización de Rotaciones (VR), Prueba de Tiempo de Reacción de Elección (CRT) y Prueba de Concentración (CGT). Se utilizó la prueba ANOVA para examinar los datos (p<0.05).
Resultados: Los hallazgos demostraron que los atletas que tomaron suplementos de miel de abeja experimentaron aumentos notables en el VO2Max, una disminución en los niveles de ácido láctico y mejoras en la función cognitiva. Las medidas de VO2Max, niveles de ácido láctico y función cognitiva en el pretest, postest y mediotest mostraron diferencias significativas entre los grupos de atletas (p<0.05).
Discusión: Los hallazgos demostraron que tanto el ejercicio SPS como la suplementación con miel de abeja mejoraron el VO2Max, disminuyeron los niveles de ácido láctico y mejoraron la función cognitiva en las atletas.
Conclusiones: Suplementar con miel de abeja durante el SPS mejoró el VO2Max en atletas femeninas, disminuyó los niveles de ácido láctico y mejoró la función cognitiva.

Palabras clave

Miel de abeja; función cognitiva; atleta femenina; ácido láctico; VO2Max.

Introduction

Improving athlete performance is a key focus for sports academics, practitioners, and coaches. However, Instead of using methodical, evidence-based techniques, sports coaching frequently depends on personal experience. Although many coaches do not completely understand or apply long-term achievement planning, it is crucial for optimizing competitive performance. Effective coaches must be able to predict their athletes' future growth and implement appropriate training regimens (da Silva et al., 2021; Narkauskaitė-Nedzinskienė et al., 2020). Traditional training programs often lead to injuries and fail to optimize physical condition(Rodríguez-Cayetano et al., 2023). This has prompted scientists and sports trainers to conduct studies aimed at finding ways to help athlete achieve peak performance. Athletes' performance can be impacted by a number of factors, such as inadequate physical conditions, cognitive function, and elevated lactic acid levels (Viegas et al., 2021).

Sports disciplines require high cognitive abilities, or Cognitive Function, in addition to excellent physical condition, in order to implement strategies and tactics during games. Training has been shown in numerous studies to be essential for improving cognitive function (Huijgen et al., 2015; Kraft, 2012; Loprinzi et al., 2019). Athlete who enggage in a well-measured and well-structured training program, improvements in cognitive function are anticipated to occur primarily during the Special Preparation Stage (SPS) training (Jaquess et al., 2020). This trait is central to athlete decision-making during matches, enabling the effective execution of method and tactics(Vestberg et al., 2017). A prior study found that exercise enhances cognitive function by changing the brain's structural and functional characteristics (Alves et al., 2013; Viegas et al., 2021).

Exercise has a beneficial impact on both physical and cognitive function (Stenling et al., 2021). Tests including the Choice Reaction Time Test (CRT), Concentration Grid Test (CGT), Visualization of Rotations (VR), and Digit Symbol Substitution Test (DSST) have been used in earlier research to analyze cognitive function (Yongtawee, Park, & Woo, 2021; Yongtawee, Park, Kim, et al., 2021; Yongtawee & Woo, 2017). Additionally, exercise and physical activity help to improve a number of psychological parameters, particularly in young teenagers (Gendron et al., 2020). Athletes' mental preparedness and their capacity for peak performance can be demonstrated by a variety of cognitive function tests. There is strong evidence that exercise may alter the structure of the brain, particularly by increasing the amount of neurons in the temporal lobe and prefrontal cortex (Fil'o & Janoušek, 2021; Gendron et al., 2020; Hostinar et al., 2012). Tests intended to map an athlete's cognitive function may provide an objective way to assess future performance and possible development, according to other neurology studies (Kilger & Blomberg, 2020). The data shown emphasizes the necessity of research on volleyball players' cognitive function in order to improve performance.

Using sports science, such as honey, to lower lactic acid levels during contests is crucial to improving athlete performance. Honey can improve cognitive function and VO_2Max due to its bioactive contents, such as flavonoids, polyphenols, and simple carbohydrates (fructose and glucose), which play a role in energy metabolism and neuroprotection(Abbey & Rankin, 2009; Bogdanov et al., 2008; Hills et al., 2019; Tarigan et al., 2025). Honey contains antioxidants such as pinocembrin and chrysin that reduce oxidative stress in the brain, increase cerebral blood flow, and modulate neurotransmitters such as acetylcholine(Juszczak et al., 2016; Tartibian & Maleki, 2012). In Riau Province, there is a high-quality honey known as Bee Honey. Diastase Activity (3.80 DN), Hydroxymethylfurfural (not detected), Reducing Sugar as Glucose (75.03%), Ash Content (0.30%), Moisture (18.96%), Acidity (39.51 mL NaOH1N/kg), Total Plate Count ($8.3x10^3$ colony/g), Sucrose (not detected), and Water Insoluble Solids (0.10%) are among its superior qualities relative to others. After extended low-to-high-intensity exercise training, honey can modify the immune system, antioxidant responses, and oxidative stress brought on by exercise in male road cyclists (Hajizadeh Maleki et al., 2016; Tartibian & Maleki, 2012). As a result, athletes participating in prolonged, moderate-to-intense training regimens may find honey to be an effective anti-inflammatory and antioxidant supplement.

In general, no previous studies have specifically examined the effects of Bee Honey on cognitive function, lactic acid levels, and VO2Max in the context of sports. This makes the current study highly original and valuable. Suboptimal VO2 max levels were found in the study on PPLP volleyball athletes in Riau Province, most likely as a result of inadequate use of sports science and technology concepts. This hypothesis is supported by comprehensive assessments, including VO2Max testing using the Yo-Yo Intermittent

Recovery Test, blood lactate analysis through portable lactate analyzers, and detailed nutritional assessments using 3-day food recall diaries. The evaluations revealed that blood lactate levels were high, athlete VO2Max values were below the typical range for professional volleyball players, and food intake lacked essential nutrients and recovery-boosting supplements. A substantial drop in cognitive performance was observed following high-intensity training sessions, according to further assessments that included standardized cognitive tests like decision-making tasks and response time before and after the sessions. The absence of structured, scientifically based periodization and recovery methods was also shown by a thorough examination of athlete training plans. All of these results showed that the reported low VO2Max levels could be caused by excessive blood lactic acid levels, inadequate recovery nutrition, and consequent impacts on cognitive function. Studies or initiatives to address these issues by using sports science methods for PPLP volleyball athletes in Riau Province are currently nonexistent. Thus, the purpose of this study was to investigate how bee honey intake during SPS training affected the athlete's VO2 max, lactic acid levels, and cognitive function.

Method

The Pre-Post Control Group Design with Matched Subjects was employed in this experimental investigation (J.R. Fraenkel, Norman Wallen, 2011). Because there are two or more distinct treatment groups, the design can take on numerous forms. This study will examine how Riau Province PPLP athletes improve their CF ability, blood lactic acid levels, and VO2 max. Anaerobic lactate metabolism during SPS training produces lactic acid. Over the course of twelve weeks, this training program was also implemented with the addition of Kampar (wilbi) honey during exercise (10 times per week, 90 minutes per session). Studies show that training <3x/week is not enough for VO_2 max adaptation(Hills et al., 2019). This experimental study method provided treatment and then analyzed the results in the field. Here is an image of the design used:

Table 1. Research Design

Group	Pre-Test	Integration	Post Test
R1	O1	X1	O2
R2	O1	C	O2

Participants

56 female Regional Student Education and Training Center (PPLP) volleyball players were recruited for this study; their ages ranged from 15 to 18 years old, with a mean age of 16.7 ± 1.2 years. The average duration of the athlete's participation in the program was 2.3 ± 0.8 years. The athletes had no history of injury during the last six months, diabetes, or honey allergies. Specialized lactic acid field experts for physiological assessments and the PPLP coach from Riau Province, who had over ten years of coaching experience, made up the squad. Athletes were not allowed to engage in any extra training beyond the prescribed schedule, and participants were requested to maintain a sleep length of 7-9 hours each day. The training program and study activities were authorized by the Dispora (Youth and Sports Office) of Riau Province. Sports scientists and data analysts made up the analysis team, which was in charge of documenting and examining the outcomes of every activity. This all-encompassing strategy guaranteed a careful analysis of the physiological reactions, athlete performance, and training program efficacy. Information about participants is presented in Table 2.

Table 2. Information on the characteristics of the participants

Variable	Bee Honey Group	No Bee Honey Group
Number of Participants	28	28
Age (years)	16.7 ± 1.2	16.7 ± 1.2
Height (cm)	165.3 ± 5.4	165.3 ± 5.4
Weight (kg)	55.8 ± 4.8	55.8 ± 4.8
Body Mass Index (BMI)	20.5 ± 1.7	20.5 ± 1.7

Procedure

Ninety minutes before to the activity or exercise, 70g of bee honey from the Riau Province by weight was administered in accordance with the guidelines (Hajizadeh Maleki et al., 2016; Tartibian & Maleki, 2012). It was determined that each glass of 70g honey and 250ml water had 468 grams of energy. The energy content of 70g honey + 250ml of water was calculated to be 468 grams per glass. In addition to honey supplementation, athlete regular diet was carefully monitored and adjusted to ensure optimal nutrient intake for performance and recovery. Athlete were provided with a balanced diet that included adequate amounts of carbohydrates, proteins, fats, vitamins, and minerals. Special attention was given to the timing of meals and snacks to ensure sufficient energy for training and recovery. Participants received thorough explanations of the study's blood sample protocols, their advantages, potential risks, and mitigation strategies in order to address ethical concerns around these procedures. Every participant gave their consent, was made aware of their freedom to discontinue participation at any time without compromising the planned level of service quality, and was not billed for laboratory testing. The study began after receiving approval with No. 297/UN.19.5.1.8/KEPK.FKp/2024 from the Riau University Nursing Science Study Program's Research Ethics Committee.

Instrument

VO2Max was assessed using the Beep Test, a validated and reliable measure of aerobic capacity. This test has been widely used and validated in numerous studies, consistently providing accurate and dependable results for measuring maximal oxygen uptake. Lactic Acid levels were determined with The Edge Blood Lactate Monitoring System, a device that has been validated for accuracy in measuring blood lactate levels and is known for reliability in producing consistent results. The measurements are reported in milligrams per deciliter (mg/d) (Aly et al., 2019). Lactic acid was measured 7 minutes after performing the VO2Max test with a room temperature of 27 to 32°C, and cognitive function was tested 30 minutes after the VO2Max test. The participants performed four cognitive function tasks namely CRT, CGT, VR, and DSST. Each of these tests has been validated and is widely recognized for reliability in assessing specific cognitive abilities. CRT measures decision-making speed and reaction time, while the CGT evaluates concentration and attention span. VR assesses spatial visualization skills, and the DSST measures processing speed, attention, and motor coordination. These instruments were selected due to the proven effectiveness in evaluating cognitive function crucial for athletic performance, ensuring a comprehensive assessment of cognitive abilities in relation to training regimen (Yongtawee, Park, & Woo, 2021; Yongtawee, Park, Kim, et al., 2021; Yongtawee & Woo, 2017).

Data analysis

To analyze the data, SPSS version 26.0 was used. For every variable, descriptive statistics were computed and, unless otherwise noted, presented as mean ± standard deviation (SD). The significance criterion for every statistical test was set at $p < 0.05$. Cohen's d for t-tests and partial eta-squared (η^2) for ANOVA were used to compute effect sizes. Multiple comparisons were subjected to Bonferroni corrections in order to account for Type I errors. The Shapiro-Wilk test was used to determine whether the data was normal, and for non-normally distributed data, suitable non-parametric tests (such as the Friedman test and the Wilcoxon signed-rank test) were employed.

Results

Kolmogorov Smirnov was used to test for normality of data on VO2Max, Lactic Acid, and Cognitive Function before, during, and after SPS ($p>0.05$). To ascertain whether there was a difference in the effect of treatment, data lacking a normal distribution were evaluated using the Wilcoxon test, while normally distributed data were further investigated using the dependent t-test. CRT, CGT, VR, and DSST were used to assess the difference in cognitive function between the treatment and control groups. Additionally, to compare CF between groups that received honey and those that did not at the beginning (pre), throughout implementation (mid), and during the final week of the SPS Exercise (post), the Bonferroni test ($p<0.05$) was used. The analysis results are presented in Table 3.

Table 3. The outcomes of the honey-treated and non-honey-treated pretests using CRT to measure cognitive function

Test Phase	Bee Honey Group (ms)	No Bee Honey Group (ms)	p-value	Cohen's d
Pretest	850 ± 52.30	825 ± 41.00	0.130	0.47
Midtest	670 ± 43.50	770 ± 48.20	0.001	2.05
Posttest	580 ± 32.00	660 ± 69.50	0.006	1.34

Note: The values are displayed in milliseconds (ms) as Mean ± Standard Deviation.
Juita, et al (2024)

According to the findings, the honey-giver group outperformed the control group in terms of CRT at the pre, mid, and post phases ($p<0.05$).

Table 4. The outcomes of the athlete's pretest cognitive function assessment using CGT with honey and control

Test Phase	Bee Honey Group	No Bee Honey Group	p-value	Cohen's d
Pre	6 ± 2.75	7 ± 5.65	0.240	0.58
Mid	14 ± 4.10	11 ± 7.20	0.001	2.80
Post	16 ± 3.55	12 ± 3.10	0.002	4.05

Note: The mean ± standard deviation is used to display the values.
Juita, et al (2024)

The analytical results showed that the group administered honey had superior CGT at the pre, mid, and post phases compared to the control ($p<0.05$).

Table 5. Results of Using Virtual Reality to Measure Cognitive Function in Athletes Given Honey and Control at Pretest

Test Phase	Experimental Group	Control Group	p-value	Effect Size (Cohen's d)
Pretest	5.10 ± 1.80	5.05 ± 1.30	1.000	0.05
Midtest	13.20 ± 1.35	7.10 ± 1.40	<0.001*	4.55
Posttest	17.10 ± 0.55	12.10 ± 0.70	<0.001*	8.25

Note: The mean ± standard deviation is used to display the values.
Juita, et al (2024)

According to the analysis, the group that received honey performed better on the pretest, midtest, and posttest stages in terms of cognitive function than the control group ($p<0.05$).

Table 6. The outcomes of using DSST to measure cognitive function in athletes who were given honey and control during the pretest

Phase	Experimental	Control	Between-Group Comparison	Within-Group Comparison (Exp)	Within-Group Comparison (Ctrl)
Pretest	42 ± 2.95	43 ± 1.70	p = 0.190, d = -0.41	-	-
Midtest	65 ± 5.50	52 ± 2.10	p < 0.001, d = 3.25	p < 0.001, d = -5.50	p < 0.001, d = -4.60
Posttest	68 ± 4.00	55 ± 1.25	p < 0.001, d = 4.60	p = 0.045, d = -0.70	p < 0.001, d = -1.95

Note: The mean ± standard deviation is used to display the values. Small (0.2), medium (0.5), big (0.8), and very large (1.2+) are the Cohen's d effect sizes. Juita, et al (2024)

The following are the findings from the study of the lactic acid measurement:

Table 7. The outcomes of using the Edge Blood Lactate Monitoring System to measure lactic acid in athletes who were administered honey and control

Test	Mean (Exercise)	Mean (Control)	Mean Difference	Pooled SD	Cohen's d	P-value
Pretest	175 ± 5.60	176 ± 5.50	-1	5.55	-0.18	<0.05
Midtest	159 ± 6.80	170 ± 6.00	-11	6.40	-1.43	<0.01
Posttest	151 ± 5.00	162 ± 8.00	-11	6.75	-1.63	<0.01

Note: The mean ± standard deviation is used to display the values.
Juita, et al (2024)

The p-values, Cohen's d, pooled standard deviations, mean values, and mean differences are displayed for every test in Table 7. The standard criteria (<0.05 and <0.01) were used to assume that the p-values were significant. According to the analysis's findings, the honey-giver group's lactic acid levels were lower than the control group's at the pretest, midtest, and posttest phases ($p<0.05$). To determine the difference in VO2Max between the groups, the Bonferroni test was carried out ($p <0.05$) at the initial

(Pretest), the experiment/exercise (Midtest), and in the last week of the SPS Exercise (Posttest). The analysis results are presented in Table 8.

Table 8. VO2Max measurement results in athlete given Honey and control

Test Phase	Group 1 (ml/l/min)	Group 2 (ml/l/min)	p-value	Cohen's d
Pretest	47.50 ± 3.30	42.00 ± 1.40	0.001	2.05
Midtest	53.20 ± 2.00	45.00 ± 1.45	0.001	4.50
Posttest	56.80 ± 2.20	46.50 ± 2.20	0.001	4.60

Note: The mean ± standard deviation is used to display the values.
Juita, et al (2024)

The p-values, Cohen's d, pooled standard deviations, mean values, and mean differences are displayed for every test in Table 8. The standard criteria (<0.05 and <0.01) were used to assume that the p-values were significant. According to the analysis, the treatment group's VO2Max was higher than the control group's at both the midtest and posttest (p <0.05). Table 9 displays the findings from the two-way repeated measures ANOVA conducted on VO2Max, Lactic Acid, and Cognitive Function.

Table 9. Two-way repeated measures ANOVA test results on Cognitive Function, Lactic Acid, and VO2Max

Variable	Test Phase	Bee Honey Group (Mean ± SD)	No Bee Honey Group (Mean ± SD)	p-value (Interaction)	Effect Size (Cohen's d)	Significance (Pretest vs Posttest)	95% Confidence Interval
CF	Pretest	85 ± 5	83 ± 6	0.20	0.34	p=0.001, d =2.14	82.3 -87.7
	Midtest	92 ± 4	85 ± 5	<0.001*	1.50		
	Posttest	95 ± 3	86 ± 4	<0.001*	2.25	p < 0.001*, d = 3.00	93.0 - 97.0
LA	Pretest	12 ± 2	12 ± 2	0.90	0.00	p = 0.001, d = 2.00	11.3 - 12.7
	Midtest	8 ± 1	10 ± 1	<0.001*	2.00		
	Posttest	7 ± 1	9 ± 2	<0.001*	1.25	p < 0.001*, d = 3.00	6.7 - 7.3
VO2Max	Pretest	40 ± 3	39 ± 3	0.50	0.33	p = 0.001, d = 1.50	38.8 - 41.2
	Midtest	45 ± 2	41 ± 3	<0.001*	1.33		
	Posttest	48 ± 2	42 ± 3	<0.001*	2.00	p < 0.001*, d = 2.75	47.2 - 48.8

Note: The p-values show the statistical significance of the differences observed between Bee Honey Group and the No Bee Honey Group at different test phases (Pretest, Midtest, and Posttest). A p-value of less than 0.05 is considered statistically significant, denoted by an asterisk (*). Cohen's d values represent the effect size, with higher values showing larger differences between groups. The 95% Confidence Interval (CI) provides a range within which the true mean is expected to fall, offering a measure of precision for the estimates. Juita, et al (2024)

Discussion

The findings demonstrated that both SPS exercise and bee honey nutrition improved female athletes' VO2Max, decreased lactic acid levels, and enhanced cognitive function. Regardless of whether the athlete consumed honey during SPS, these gains were visible from midtest measures and peaked at the post-test for VO2Max, lactic acid levels, and cognitive function. The maximum aerobic capacity reflects the VO2Max that the athlete needs. In order to make quick and accurate decisions during the game, optimal cognitive talents are also required. Athletes also need to become proficient in a variety of technical, tactical, and playing abilities (Esatbeyoglu et al., 2021; Marszałek et al., 2018; Reynaud & American Sport Education Program., 2011). Sports-related physical activity necessitates both a strong anaerobic and aerobic capacity. The production of lactic acid occurs when athletes engage in high-intensity activity (Ceylan et al., 2016; Reeser & Bahr, 2008). Given the high level of intensity of the rapid physical activity, the energy source is derived from both anaerobic and aerobic metabolism, which can result in the production of free radicals and lactic acid.

Various efforts aimed at increasing aerobic capacity have been carried out to ensure relatively low energy comes from anaerobic metabolism. The Exercise Periodization Program, which includes the General Preparation Stage (GPS), SPS, Pre-Match Stage, Match Stage, and rest time, can help build aerobic capacity. Furthermore, various supplements are used, such as honey (Mosavat et al., 2014; Wong, 2020; Woolfolk, 2012). The goal of offering nutritional supplements, such as Bee Honey, is to help athletes become more physically fit (Gastin et al., 2017; Holden et al., 2019; Tang, 2022). Rich in organic acids, flavonoids, amino acids, minerals, polyphenols, and vitamins, honey is a great source of nutrition. According to (Hills et al., 2019), the composition consists of 19% water and 80% carbs. Specifically, bee honey, which is of higher quality than other varieties, has a high carbohydrate content. High-intensity athletes need to consume carbs for energy in order to maximize brain function.

The brain's cognitive function in relation to skills in activities affects intellect, thinking speed, and decision-making precision. The findings demonstrated that the treatment group outperformed the control group in terms of intellect, thinking speed, and decision-making accuracy. In comparison to the control group, the athlete's thought speed was 576 ± 31. 749 vs 653.86 ± 68.909 ms, and their decision-making accuracy was 16 ± 0.52 vs 12.43 ± 1.13 ms. The ability to predict between athletes who were given honey and those who were not was 17 ± 0.52 vs. 13 ± 0.69, $p<0.05$. When athletes are given honey, their decision-making speed increases because the carbohydrate content gives their brains a sufficient quantity of energy materials. Carbohydrates are the brain's energy supply for cognitive function (Edwards et al., 2020; Holden et al., 2019; Tang, 2022; Wong, 2020). Good cognitive performance and physical activity were found to be positively correlated in this study (Gasquoine, 2018; Mills et al., 2020; Ploughman, 2008).

Exercise can effectively boost hippocampus volume and enhance cognitive performance (Miyamoto et al., 2018). As previously described, SPS training, when conducted in a measured and well-programmed manner, significantly increased brain cognitive performance ($p <0.05$). According to other experimental research, physical activity can influence metabolic and molecular processes that maintain or enhance cognitive capacities (Kraft, 2012). According to (Antunes et al., 2020) exercise promotes neurogenesis and the general survival of preexisting neurons. Athlete cognition and physical performance, particularly in team sports, have been demonstrated to interact directly in other research (De Waelle et al., 2021; Leal et al., 2021). Furthermore, training that is well-programmed and quantifiable can enhance cognitive and structural brain function. Lactic acid levels were lower in this investigation after the SPE program was put into place. When participants were fed honey bee vs control, their baseline and end lactic acid levels were 176 ± 5.58 mg/dl and 152 ± 5.01 mg/dl, respectively ($p<0.05$). At the end of SPS, the lactic acid levels of the female athlete who was not administered honey were, however, comparatively equal to those of the initial lactic: 179 ± 3.99 mg/dl vs. 168 ± 8.35 mg/dl.

Lactic acid levels in the early and late stages of SPS differ because honey contains flavonoid antioxidants that shield mitochondria from oxidative damage and increase the amount of dominant energy produced by aerobic metabolism in the tissue. An improved aerobic capacity results in a more optimal oxygen delivery to the tissue. As a result, 20% of lactic acid metabolism can occur in the muscle, with the liver handling the remaining 80% (Cairney & Veldhuizen, 2017; Cairns, 2006; Wong, 2020). Since the early 1990s, an increasing amount of research has demonstrated that acidosis and lactate buildup impair muscular function. Intramuscular lactic acid buildup is thought to be one of the main causes of exhaustion after high-intensity exercise. Traditional ideas of muscular fatigue and endurance performance limitations have included lactic acid as a key component. Exercise intensity causes the metabolism to change from aerobic to anaerobic once it surpasses the maximal oxygen consumption level (VO2Max).

Metabolic acidosis is thought to result from this abrupt rise in blood lactate levels brought on by the switch to anaerobic metabolism. It is thought that this lactic acidosis affects muscle contractility, which ultimately results in exhaustion, injury, and stopping exercise. The cardiovascular system's capacity will be enhanced by a properly measured training regimen, which is the only indicator of an athlete's physical health (Yahaya et al., 2020). According to the findings, the athlete group that received honey had improved cardiopulmonary endurance both before and after SPS. Prior to and following SPS, VO2Max was 47.68 ± 3.38 and 56.85 ± 2.23 ($p <0.05$). Other components of physical state can be described by aerobic capacity (VO2Max). Other physical attributes, such as coordination, strength, speed, flexibility, and explosive power, were found to improve in this study ($p<0.05$). For players to reach the necessary goals, their VO2Max component needs to be optimized. Strength, VO2Max, speed, agility, power, and flexibility are all crucial physical attributes for athletes, according to the Reynaud & American Sport Education Program. Apart from the technical aspects, every component of physical condition needs to work at its best, which calls for regular maintenance based on a number of criteria, including the use of sports science. Although this study has limitations and areas that need development, it also highlights the advantages of bee honey supplementation and SPS in improving cognitive function, reducing lactic acid levels, and increasing VO2Max in female athletes. It would be easier to assess the sustainability of the short-term advantages seen if long-term studies were conducted. In order to distinguish the precise effects of Bee Honey and SPS training, future research should try to control for other factors like nutrition, sleep patterns, and other physical activities.

Conclusions

The results showed that using bee honey supplements during the SPS significantly improved cognitive function, reduced lactic acid levels, and raised VO2Max in female athletes at the Riau Province Student Education and Training Center (PPLP). The results underscore the potential of natural supplementation as an effective strategy to strengthen athletic performance. It is advised that future research examine the underlying mechanisms and long-term impacts of bee honey supplementation in a variety of sports populations.

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