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RESEARCH ARTICLE

Nutritional Status and Cardiometabolic Markers to Determine Athlete's Achievement: A Cross-Sectional Study

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Abstract
The health, physiological, and nutritional status of an athlete is a top priority in achieving success and career sustainability. Information about an athlete's health, such as blood biochemistry, anthropometry, and adequate nutritional intake, might indicate their ability to perform exceptionally well in different levels of competition. Objective: This research objective is to examine the correlation between athletes' sports achievements in Bandung and their anthropometric traits, nutritional status, and blood biochemical indicators. Methods: This study utilised a cross-sectional design and incidental data collection techniques. Participants: The study comprised 84 athletes from 27 different sports who received achievement allowances from KONI Bandung City. Instruments: n this study, we employed reliable and validated techniques to assess anthropometrics, body composition, somatotype, blood biochemistry, nutritional intake adequacy, and energy adequacy. Data analysis: Both the bivariate and multivariate analyses used logistic regression. Results: The findings of the analysis indicate a significant relationship between athlete performance and two variables: blood pressure (p=0.026) and dietary diversity (p=0.048). The findings from the multivariate analysis revealed a significant relationship between blood pressure and dietary variety, which influences the achievement of athletes. The calculation of the odds ratio (OR) revealed that among all the variables examined, the athlete's blood pressure exhibited strongest correlation with their performance. Conclusion: Blood pressure is a physiological measurement that can serve as an indicator of cardiac function and overall well-being. As a result, it is critical to regularly assess the physical well-being of athletes in Bandung to ensure their consistent optimal performance.

Keywords
Athlete, Athlete's Achievement, Blood Pressure, Health

INTRODUCTION

The attainment of optimal health and performance in athletes is contingent upon the crucial consideration of optimal nutrition (Holtzman & Ackerman, 2021). Maintaining good health and enhancing physical fitness, with the aid of proper nutrition, is fundamental to creating a conducive environment for athletes to engage in practical training and achieve successful performance outcomes (Arent et al., 2020). The consumption of appropriate nutrients is associated with optimal athletic performance, while lacking nutrients may result in reduced performance (Hornstrom et al., 2011). Nutrition also plays a great role in injury prevention, skeletal muscle regeneration, health maintenance, and performance enhancement (Holway & Spriet, 2011; Toptaş Demirci & Lourenço, 2024).

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The nutritional requirements of athletes vary based on their specific sport's pursuits. However, athletes must maintain a balanced diet that includes appropriate amounts of macronutrients and adequate hydration to achieve optimal performance and maintain overall health. In addition, evaluating nutritional status is crucial for optimizing performance due to its impact on health, body composition, and overall performance (Mielgo-Ayuso et al., 2015). According to (Bytomski, 2018), it is imperative to evaluate the energy needs of athletes following the specific demands of their respective sports and their training objectives. It is advisable to ensure that athletes consume sufficient macronutrients, including protein, carbohydrates, and fat, from various dietary sources, including unrefined carbohydrates, such as whole-grain bread and cereals, as an essential element in dietary interventions (Seal et al., 2021).

Furthermore, an athlete's vitamins and minerals need to be fulfilled through a balanced and carefully designed dietary regimen, as suggested by Nebl (Nebl et al., 2019). Moreover, it is necessary for athletes to adequately ingest fluids to achieve optimal hydration levels before, during, and after physical activity, thereby sustaining peak performance (Kim et al., 2018). Hence, each athlete needs to comply with personalized nutritional protocols, necessitating the coach and athlete to possess extensive expertise to ascertain suitable caloric, macronutrient, micronutrient, and hydration consumption under the athlete's requirements and training objectives.

In addition to nutritional considerations, elite athletes undergo a range of physiological adaptations that substantially influence their sports performance. Genetic polymorphisms at the physiological level were associated with specific phenotypes characterized by anthropometric and functional traits that impose conditional and physiological requirements on sport performance (Garcia et al., 2022). The adaptations may encompass alterations in muscle morphology, cardiovascular performance, and metabolic pathways, among other variables. Typically, high-performance athletes undergo various physiological adaptations contingent upon their specific sport, exercise regimen, and competitive level (Etxebarria et al., 2019). Utilization of physiological monitoring is employed in individual sports to assess the dose-response, intensity, and performance of the exercise. The study evaluates the efficacy of various equipment coaches use for measuring physiological performance and biochemical parameters (Kiely et al., 2019).

Various biochemical parameters that may be employed include blood glucose levels, hemoglobin (Hb) concentrations, cholesterol levels, and ketone levels. Kiely et.al described a positive correlation between normal sugar levels and enhanced athlete performance, while a negative correlation was observed on individuals experiencing hypoglycemia, suggesting a decline in performance (Kiely et al., 2019). Iron plays a crucial role in oxygen transportation as it is essential for the synthesis of hemoglobin. Iron is an essential element for the efficient operation of oxidative enzymes involved in intracellular metabolism, specifically the electron transport chain and oxidative phosphorylation pathways within mitochondria (Stoltzfus, 2001). According to Rowland, the mechanism is influenced by physical activities of short duration, such as sprints and prolonged aerobic exercise (Rowland, 2012).

Blood pressure measurement is a frequently utilized cardiovascular parameter. The potential of blood pressure response during exercise testing to reveal previously undetectable cardiovascular pathology and predict future cardiac disease risk was acknowledge in both the general population and in pre-participation screenings of athletes (Caselli et al., 2019). Therefore, understanding the parameters that define a typical or atypical blood pressure response during exercise is essential to assessing cardiovascular health.

The limited information on athletes' physiological conditions is a concern in Indonesian sports development, particularly in Bandung. Athletes from the city of Bandung have high potential to win competitions at the international level. The city of Bandung makes various efforts to foster the achievements of its athletes. Evaluations often focus solely on physical conditions, neglecting fundamental aspects like anthropometry, physiological conditions, and nutritional adequacy. Nevertheless, additional research is needed to investigate the importance of additional factors that influence athlete's achievement. The objective of this study was to examine the determinants that are associated with the accomplishments of elite athletes from Bandung.

MATERIALS AND METHODS

Research Design

This study investigates the correlation between athlete performance at both national and international levels and many factors including health conditions, blood biochemistry, anthropometry, and nutritional adequacy. Figure 1 displays the research design used in this study.

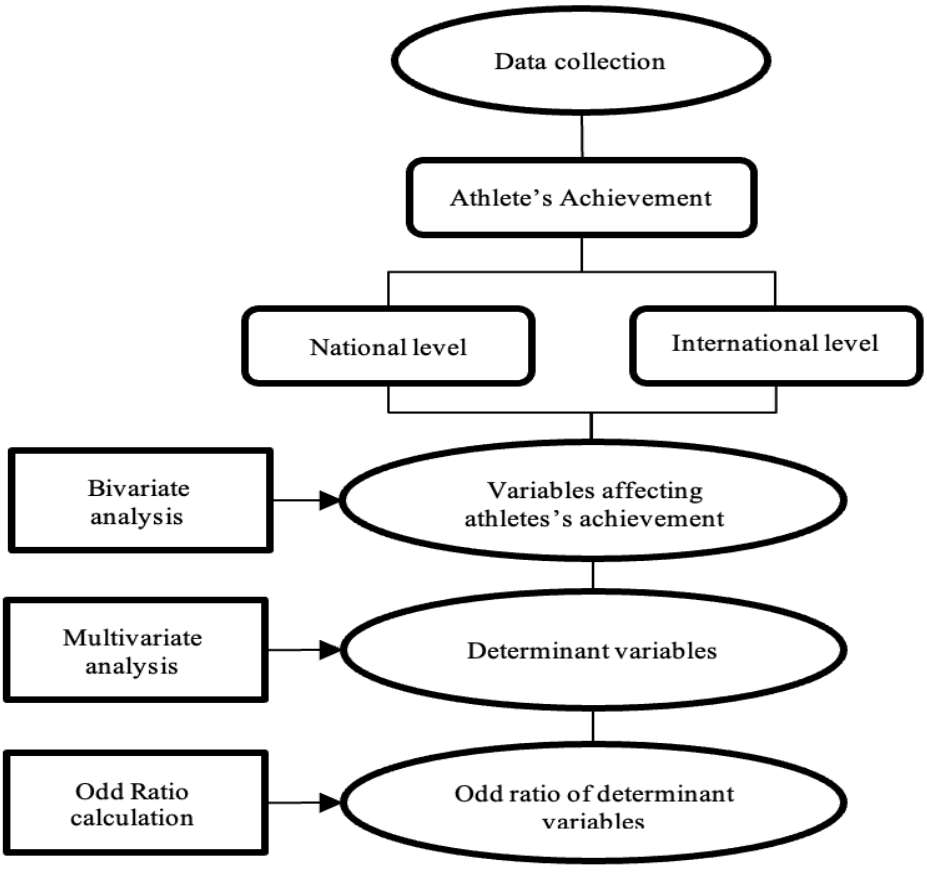

Figure 1. Researh design

Participants

The Medical and Health Research Ethics Committee (MHREC), Gadjah Mada University, Indonesia, granted ethical approval for the study with reference number KE/FK/0962/EC/2022, following the guidelines specified in the Helsinki Convention. Participants provided informed consent via the volunteer form, which included information about the research, potential risks and benefits, confidentiality, and participant rights. The research carefully followed the ethical standards outlined in the Declaration of Helsinki, with a focus on safeguarding the rights and well-being of the participants through careful consideration of the study's design, procedures, and confidentiality measures.

The study included athletes from KONI Bandung City who received an achievement allowance. The reported population consisted of 110 individuals. The Slovin formula determined the sample size, resulting in a minimum sample size of 75 individuals. Furthermore, the total sample size was 84 people, based on an expected dropout rate of 10%. The study employs incidental sampling as its sample technique. The study's inclusion criteria consisted of athletes who were free from infectious diseases, not enrolled in a weight management program, and willing to actively participate in data collection activities. This study excluded athletes who were absent during data collection and athletes who did not fully complete the questionnaire.

Data Collection Tools

There are several instruments used in this study including body scales, stadiometer, measuring tape, and skinfold caliper which are used to measure anthropometric aspects of the body. A digital tensimeter was used to measure blood pressure and pulse rate. Blood biochemical

parameters were measured using a set of readers and test strips from Accutrend and Fora-6. Karada Body Composition Scanner was used to measure body composition. The 24-hour food recall method was used to determine nutritional adequacy (Anderson et al., 2017), while the diversity of athlete's consumption was assessed using the Individual Dietary Diversity Score (IDDS) (Habte & Krawinkel, 2016). The adequacy of energy intake was determined through the Energy Availability calculation (Melin et al., 2019).

Procedures

Professionals with the necessary qualifications and expertise carry out all measurement activities. Data collection procedures were used using interview techniques and direct measurement. Interview techniques were used to obtain data on athlete achievement, athlete characteristics, nutritional adequacy measurements, and diversity of athlete food consumption. Direct measurement techniques were used to measure blood pressure and pulse rate. The same applies to anthropometric measurements such as body mass index, body composition, and somatotype. Measurement of blood biochemical parameters was carried out on capillary vessels to obtain data on haemoglobin values, blood glucose, triglycerides, and ketones. Energy availability is calculated by subtracting the energy spent through physical activity (energy expenditure) from the energy consumed through food and drink (energy intake).

Data Analysis

IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Chicago, IL, USA) was used to conduct a descriptive, bivariate, and multivariate analysis. The variables were subjected to bivariate analysis to identify the independent variable that meets the requirements for conducting multivariate logistic regression analysis. Further investigation was carried out using a multivariate model on independent variables with p-values less than 0.25.

RESULTS

A study was conducted with a sample size of 84 athletes, selected from a population of 110 individuals. The study includes athletes from 27 distinct sports, including aero-modeling, weightlifting, athletics, billiards, bodybuilding, bowling, badminton, chess, hang gliding, wrestling, judo, karate, sailing, diving, open water swimming, archery, rock climbing, pencak silat, swimming, fin swimming, gymnastics, roller skating, water skiing, squash, taekwondo, tarung derajat, and wushu. The independent variable in this research was sports accomplishments, which are classified into national and international level. The study examined several independent variables pertaining to the athlete's nutritional profile. These variables encompassed age, gender, nutritional status, subcutaneous fat, visceral fat, muscle mass, blood pressure, pulse, hemoglobin level, triglyceride level, ketone level, energy availability, nutritional adequacy, and adequacy of protein.

The results of the bivariate analysis conducted using logistic regression are provided in Table 1. The findings suggest that the variable associated with athlete's achievement is blood pressure, with a statistically significant p-value of 0.038. Most participants, encompassing athletes at both national and international levels, exhibit blood pressure within the normal range. The prevalence of hypotension was found to be greater among international athletes, with a percentage of 9%. In contrast, athletes at the national level demonstrated a greater prevalence of hypertension, with a rate of 8%. Additionally, multivariate analysis was conducted by incorporating additional variables that exhibited a p-value of less than 0.25. The variables that were subjected to further analysis using the multivariate analysis model are blood pressure (p=0.038), dietary diversity (p=0.064), subcutaneous fat (p=0.249), ketones (p=0.135), and carbohydrate adequacy (p=0.238).

Table 2 presents the result from multivariate analysis of independent variables, namely blood pressure, dietary diversity, subcutaneous fat percentage, blood ketone level, and carbohydrate adequacy. The findings of the analysis indicate a significant relationship between athlete performance and two variables: blood pressure (p=0.026) and dietary diversity (p=0.048). In addition, the irrelevant variables were systematically removed from the model. Furthermore, the variables with changes in odds ratio values exceeding 10% were reintroduced into the model for further analysis. Nevertheless, final analysis reveals that none of the variables exhibit an odds ratio exceeding 10%. As a result, the blood pressure and food diversity variables are still included in the equation.

Table 1. Association of athlete's characteristics with sports achievement

Variables		Achievement		*p-value*
		National (%)	International (%)	
Age	_ Teen	27 (32.1)	31(36.9)	
	– Adult	11 (13.1)	11(13.1)	0.943
	– Elderly	3 (3.6)	1 (1.2)	
Sex	– Male	22 (26.2)	21 (25)	
	– Female	19 (22.6)	22 (26.2)	0.553
Nutritional Status	– Underweight	2 (2.4)	3 (3.6)	
	– Normal	25 (29.8)	28 (33.3)	0,954
	– Overweight	5 6)	5 (6)	
	– Obese	9 (10.7)	7 (8.3)	
Subcutaneous Fat	– Low	7 (8.3)	11 (13.1	
	– Normal	29 (34.5)	30 (35.7)	0.249
	– High	5 (6)	2 (2.4)	
Visceral fat	– Low	5 (6)	9 (10.7)	
	– Normal	26 (31)	27 (32.1)	0.742
	– High	10 (11.9)	7 (8.3)	
Muscle Mass	– Low	13 (15.5)	9 (10.7)	
	– Normal	26 (31)	32 (38.1)	0.524
	– High	2 (2.4)	2 (2.4)	
Blood pressure	– Hypotension	3 (3.6)	9 (10.7)	
	– Normal	30 (35.7)	32 (38.1)	**0.038**
	– Hypertension	8 (9.5)	2 (2.4)	
Pulse	– Normal	41 (48.8)	40 (47.6)	0.999
	– Fit		3 (3.6)	
Hemoglobin	– Anemia	6 (7.1)	6 (7.1)	0.427
	– Normal	35 (41.7)	37 (44)	
Triglycerides	– Dyslipidemia	7 (8.3)	8 (9.5)	0.787
	– Normal	34 (40.5)	35 (41.7)	
Ketones	– High	27 (32.1)	31 (36.9)	0.135
	– Normal	14 (16.7)	12 (14.3)	
Energy availability	– Low	33 (39.3)	36 (42.9)	0.942
	– Normal	8 (9.5)	7 (8.3)	
Energy adequacy	– Low	25 (29.8)	26 (31)	0.636
	– Good	8 (9.5)	10 (11.9)	
	– High	8 (9.5)	7 (8.3)	
Protein adequacy	– Low	21 (25)	26 (31)	0.297
	– Good	10 (11.9)	8 (9.5)	
	– High	0 (11.9)	9 (10.7)	
Carbohydrate adequacy	– Low	27 (32.1)	29 (34.5)	0.238
	– Good	11 (13.1)	13 (15.5)	
	– High	3 (3.6)	1 (1.2)	
Fat adequacy	– Low	17 (20.2)	18 (21.4)	0.819
	– Good	10 (11.9)	10 (11.9)	
	– High	14 (16.7)	15 (17.9)	
Food diversity	– Less	20 (23.8)	30 (35.7)	0.064
	– Diverse	21 (25)	13 (15.5)	

Table 2. Multivariate analysis of variables associated with athlete's achievement

Variables	B	S.E.	Wald	df	Sig.	OR
Blood pressure	-1.219	.548	4.955	1	**.026**	.295
Food diversity	-.965	.487	3.917	1	**.048**	.381
Subcutaneous fat	-.336	.484	.483	1	.487	.714
Ketones	-.610	.531	1.323	1	.250	.543
Carbohydrate adequacy	-.398	.424	.883	1	.347	.672

Constant	5.798	1.946	8.872	1	.003	329.526

The multivariate analysis results for the variables determining sport performance are shown in Table 3. There is a significant association between blood pressure and athlete performance, with blood pressure showing the highest level of correlation. The odds ratio (OR) of both variables is less than 1, suggesting that they are classified as protective variables. Therefore, this study concludes that blood pressure serves as an important indicator in predicting and protecting the performance of athletes at the international level. Athletes who exhibit limited dietary diversity may experience a 40% reduction in their likelihood of attaining international accomplishments compared to athletes who maintain a diverse dietary intake

Table 3. Association of nutritional parameters and athlete's achievement

Variables	B	S.E.	Wald	df	Sig.	OR
Blood pressure	-1.245	.520	5.723	1	.017	**.288**
Food diversity	-.916	.477	3.684	1	.055	**.400**
Constant	3.795	1.292	8.630	1	.003	44.459

DISCUSSION

An athlete's physical well-being plays an important role in determining their level of accomplishment in sports. This study revealed a significant association between blood pressure and the performance outcomes of elite athletes in Bandung. Blood pressure refers to the measurement of pressure in the primary arterial system of the human body, typically expressed in millimeters of mercury. The measurement is characterized using systolic and diastolic pressure. The diastolic pressure refers to the minimum pressure observed just prior to the subsequent ventricular contraction, whereas the systolic pressure corresponds to the maximum blood pressure recorded during the contraction of the ventricles. Blood pressure is commonly represented as the combination of systolic and diastolic pressure, such as 120/80 mm Hg (Brzezinski, 1990).

Extensive research has been conducted on the cardiac condition and its correlation with the well-being of athletes, with particular emphasis on the role of the left ventricle. The left ventricle is responsible for receiving oxygenated blood from the right atrium and distributing it to various regions of the body. According to previous studies, there appears to be a correlation between vigorous physical exertion and myocardial disturbances, which subsequently heightens the likelihood of sudden death among athletes (Corrado et al., 2003; Kim et al., 2018). Nevertheless, previous research has indicated that the right ventricle undergoes both structural and functional adaptations in response to the workload it encounters (Hauser et al., 1985; Scharhag et al., 2002).

The present study revealed a notable disparity in the occurrence of hypertension between international athletes (2.4%) and athletes participating at the national level (9.5%). Hypertension is a physiological state characterized by a systolic blood pressure (SBP) equal to or greater than 140 mm Hg, or a diastolic blood pressure (DBP) equal to or greater than 90 mm Hg. The threshold for blood pressure in individuals with hypertension, as typically established, is equal to or greater than 130/85 mm Hg (Helzberg et al., 2010). Hypertension, a clinical manifestation, frequently manifests in athletes, with several studies indicating that athletes exhibit elevated blood pressure levels compared to individuals who do not engage in athletic activities. Previous study showed, the occurrence of hypertension among athletes exhibits considerable variation, ranging from 0% to 83% (Berge et al., 2015). This variability is influenced by factors such as gender, race, age, type of sport, duration of exercise, and nutritional status. Sex was identified as a contributing factor to the variation in blood pressure measurements between male and female athletes (Schweiger et al., 2021). Previous investigations into elite volleyball, basketball, and soccer athletes have indicated that male athletes exhibited significantly higher systolic and diastolic blood pressures (Hosseinzadeh et al., 2017). However, there was no significant difference observed in heart rate between male and female athletes. Age is a variable that is recognized to impact the functional capacity of the heart; however, it has been established that young athletes

exhibit equivalent cardiac work capacity when compared to their adult counterparts. Findings from endurance athletes suggest that there were no statistically significant differences observed in the electrocardiogram and blood pressure measurements between child and adult (Pentikäinen et al., 2021).

In this research, data pertaining to athletes from a total of 27 sports, encompassing endurance, strength, and team sports, was gathered. The impact of sports characteristics on blood pressure has been widely acknowledged, with studies indicating that strength-trained athletes exhibit elevated blood pressure levels (Guo et al., 2013). The phenomenon described can arise because of prolonged endurance training, wherein the left ventricle's function, morphology, and cardiovascular function remain unaffected (Pelliccia et al., 2010). In conjunction with athletic attributes, the duration and intensity of physical activity have been identified as factors that influence hypertension. It has been observed that individuals engaged in athletic pursuits for more than 10 hours per week exhibit elevated blood pressure levels (Berge et al., 2015; Hosseinzadeh et al., 2017).

This study also investigated the extent of dietary diversity among athletes. The instrument employed in this study is the Individual Dietary Score, which is designed to assess the overall nutritional sufficiency (Gina Kennedy et al., 2013). The instrument was employed across various age and gender cohorts to establish the validity of assessing macronutrient and micronutrient sufficiency in dietary intake (Doustmohammadian et al., 2020; Isabirye et al., 2020; Shrestha et al., 2021; Verger et al., 2021). The results from this study indicate a correlation between athletes who have a narrow range of food choices and their lower probability of achieving success at the international level. Upon collection of the data, it was observed that the athletes were engaged in a phase of general preparatory phase before competition. During this phase, athletes did not receive adequate nutritional assistance. This is shown by the low variety of athletes' diets and low levels of nutritional adequacy. Moreover, it also affects the sufficiency of macronutrient intake. The insufficiency of carbs, protein, and fat among athletes is demonstrated by the data presented in Table 1.

Numerous studies have reported the significance of meeting the dietary needs for both macronutrients and micronutrients in relation to enhancing athletic performance (Victor Lun et al., 2009). Despite the implementation of nutritional supplementation, its impact on enhancing nutritional adequacy, energy levels, and the nutritional status of athletes is not substantial (Larson-Meyer et al., 2018; Rodrigues et al., 2017). Another consequence of inadequate nutritional intake is the limited energy fueling for the body. The parameter of energy availability is widely recognized as the primary measure utilized in evaluating the nutritional status of athletes (Pereira et al., 2007). Several studies have documented that a significant number of athletes across different sports suffer from energy deficiency, primarily because of inadequate understanding and awareness regarding the significance of nutrients in enhancing sports performance and promoting overall health (De Souza et al., 2019; Melin et al., 2019; Pereira et al., 2007; Taguchi et al., 2020; Thomas et al., 2016). The implementation of nutrition education has been identified as a potential strategy to promote optimal nutritional status and enhance athletic performance (Dewi et al., 2021; Foo et al., 2021; Molina-López et al., 2013). Healthy diet and nutritional awareness are essential components of disease prevention, quality of life, and the well-being of society (Murathan, 2023).

This study found that blood pressure is a crucial determinant of an athlete's success. The role of blood pressure parameters in determining an athlete's success has not been extensively studied. Furthermore, this study has shown that the variety of food types consumed by athletes has an impact on their performance, in addition to their insufficient nutritional and calorie intake. Athletes with a more varied diet have a higher likelihood of achieving success at the international level. Given the need to include a wide variety of foods in athletes' daily diets to improve their nutritional status and maintain optimal energy levels, it is crucial to continuously and regularly provide athletes with nutrition education.

Conclusion

The research revealed that of the variables analyzed in this study, blood pressure was the determining factor for an athlete to achieve at the international level. In addition, food diversity also plays a role in increasing an athlete's chances of achieving higher performance. However, this study is very general in nature because it involves a variety of athletes from different age groups and types of sports. This research can be a reference for

coaches and sports coaching organizations in determining programs and policies to improve athlete performance in the city of Bandung.

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Conflict of Interest

There is no personal or financial conflict of interest within the scope of the study.

Ethics Statement

Ethics Committee approved the study protocol (Ethics committee approval numbered KE/FK/0962/EC/2022.

Author Contributions

Conception and design of the study: SFS; Data Collection: SFS, NAN, MM, NN; Analysis and Interpretation: SFS, NAN; Draft manuscript preparation; SFS, NAN, AP, HJBJM; Final Approval of the version to be published: SFS, NAN, MM, NN, AP, HJBJM; All authors approved the final version of the manuscript.

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