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Motto in Life: Healthy, Happy, and Holistic

The Effect of Glucose on the Physical Performance of Non-Athlete Students as Measured by the Cooper Test Method of Running 2.4 Kilometers

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Physical performance is the ability of an individual's body to carry out physical activities efficiently and effectively. Carbohydrates can be the main fuel for various functions, such as physical, cognitive, and cellular activities. The main objective of this experimental study is to determine the effect of the intake of glucose, a form of carbohydrate, on the physical performance of non-athlete students when measured using the Cooper test method of running 2.4 km using a pretest-posttest group research design. The subjects were 30 non-athlete college students. Anthropometric data and physical assessments such as body weight, height, body mass index, body temperature, blood pressure, pulse rate, and blood glucose levels were measured. The length of time measured by the Cooper test method of running 2.4 km for the pre-test is 906.7±189.62 seconds. For the post-test, a 6% glucose solution was given to the subjects after a recovery period of 168 hours. The length of time measured by the Cooper test method of running 2.4 km for the post-test is 837.6±173.94 seconds. The comparative data using a t-test shows a p-value of 0.0021 ($p<.005$), which indicates a significant difference between before and after glucose intake. The subjects ran faster after being given a glucose solution. Therefore, this study concluded that glucose intake significantly affects the physical performance of non-athlete students as measured by the Cooper test method of running 2.4 km.

Keywords: *physical performance, glucose intake, Cooper test running 2.4 km*

Physical performance and physical activity have a close functional relationship. It is defined as the ability of an individual's body to carry out bodily actions ranging from everyday activities to athletic endeavors (Ceria-Ulep et al., 2011). Despite individual differences in response to regular physical activity, the higher the intensity and amount of physical activity, the better the physical performance (Bondarev et al., 2021).

Exercise and physical performance are closely interconnected. Caspersen et al. (1985) defined exercise as deliberate and structured physical activity that is planned, structured, and done repetitively to improve or maintain health and has a final or intermediate objective to improve or maintain physical fitness and overall well-being. It also significantly enhances various aspects of physical performance: cardiovascular endurance, muscle strength, muscle endurance, flexibility, balance, speed, body composition, and mental health (Kylasov and Gavrov, 2011). Physical performance can vary widely depending on an individual's fitness level, training, and skill set. Physical fitness is the body's ability to function efficiently and effectively. It refers to a state of well-being and health that results from regular exercise and physical activity (Health and Physical Education, 2023).

Many factors predict what source of fuel will be used during exercise. Proteins, fats, and carbohydrates are all possible sources of fuel for exercise and muscle contraction (Nakrani et al., 2023). Studies have shown that glucose (a simple carbohydrate) is the primary fuel source as duration and intensity increase. Carbohydrate intake before, during, and after exercise is crucial (US Anti-Doping Agency, 2023). Carbohydrate intake pre-exercise prevents hunger during exercise, provides optimal blood glucose levels for endurance exercise, and increases glycogen stores (Mayo Clinic, 2018). Glucose is obtained from the diet, primarily from carbohydrates, and is also produced by the body through processes like gluconeogenesis.

The physical fitness test measures an individual's physical abilities and fitness levels. These tests are often used in various contexts, including sports, healthcare, physical therapy, and fitness training (Quinn, 2023). A running test is one of the physical fitness assessments specifically designed to measure an individual's physical performance (Boullosa et al., 2020). It provides valuable information about an individual's speed, endurance, and running form (National Register of Personal Trainers, 2023). Running is a popular and effective form of aerobic exercise that can significantly impact physical performance and overall health by improving cardiovascular endurance as well as muscular strength and endurance. The Cooper 2.4 km (1.5 mile) run test is a simple running test of aerobic fitness. This method of physical fitness testing was designed by Kenneth H. Cooper in 1968 for the US military (Cooper Aerobic, 2009). The Cooper test, running 2.4 km, is often used in fitness assessments, physical education classes, military fitness evaluations, and other fitness evaluations. Coaches and trainers also use it to determine cardiovascular fitness and track fitness over time (Quinn, 2022). This test aims to complete the 2.4-kilometer course in the shortest possible time. Testing is easier to administer when the distance is fixed and the finishing time is measured (Translating Research Evidence and Knowledge, 2023).

This study aims to determine the effect of glucose (a simple form of carbohydrate) intake on the physical performance of non-athlete male students as measured by the Cooper test method of running 2.4 km using a pretest-posttest group research design.

Methodology

Research Design

This study utilized a pretest-posttest group research design. This research design was used for this study because it is a standard experimental research design that involves measuring subjects before they undergo a treatment and then measuring them again on the same variable after the treatment. The primary purpose of this design is to assess the effect of the treatment by comparing the pretest and post-test scores.

Population and Sampling Techniques

The study subjects were 30 non-athlete male college students, selected randomly with an age range between 19 and 23 years old (20.9±0.76 years), who were healthy and did not consume any energy drink or its kind before and during the test and did not perform any strenuous activity before the test. The ethics board of the university approved the study. Subjects were asked to fill out and sign informed consent forms before treatment.

Materials

Tools and materials utilized for this research were a bathroom weighing scale (Camry, precision 0.1) for measuring body weight and a thermometer (Thermogun Infrared, Vin Med) for measuring body temperature. Sphygmomanometer (Riester, precision 1 mmHg) and stethoscope (Littman) for measuring blood pressure, digital stopwatch (mobile phone), whistle for starting sign, stationery (pen and paper), and 400-meter running track.

The treatment materials were a 6% glucose solution of 18 grams of pure glucose (dextrose) powder or crystals dissolved in 300 milliliters of distilled water. According to Febrina (2023), the oral glucose intake dosage for adults is between 4 and 20 grams.

Experiment One (No Glucose Intake). After going through physical assessments such as body temperature, pulse rate, blood pressure, and blood glucose level (after 8 hours of fasting), the subjects ran track for a 10-minute warm-up to prepare their joints and muscles before the Cooper test, running 2.4 km, started. The test aims to complete the 2.4-kilometer course in the shortest possible time. At the start, all subjects line up behind the starting line. On the command “go,” the stopwatch was started, and they all began to run at their own pace. Walking was strongly discouraged. It was only permitted during the cool-down stage after completing the test. The total time to complete the course was recorded. The subjects then proceeded to a post-treatment physical assessment, which included body temperature, pulse rate, blood pressure, and blood glucose levels.

Recovery Stage. The subjects were going through the recovery stage for 168 hours. They were prohibited from strenuous physical activities during the recovery stage. This was a long-term recovery time. It is essential to give the body enough time to replenish energy stores and allow the damaged muscle to recover. The American Council on Exercise suggests a rest day every seven to ten days after high-intensity exercise (Ansorge, 2022).

Experiment Two (with glucose intake). The subjects underwent physical assessments such as body temperature, pulse rate, blood pressure, and blood glucose level (after 8 hours of fasting). Each of the subjects was given a glucose solution. The blood glucose level was measured again after 30 minutes of rest. The subjects were allowed to rest another 30 minutes before proceeding to the running track for a 10-minute warm-up. After completing the Cooper test, which ran 2.4 km, the subjects moved on to the post-treatment physical assessment, which included body temperature, pulse rate, blood pressure, and blood glucose levels.

Results and Discussions

The recorded data from the pretest and posttest were analyzed using a paired-sample t-test for Microsoft Excel and a p-value ($p = 0.05$).

Experiment One (No-Glucose)

Table 1 shows the mean value, standard deviation, and p-value of experiment one for the subjects without glucose before and after completing the Cooper test running 2.4 kilometers.

Table 1

Experiment One (No Glucose Intake)

Variable	Experimental One (No-Glucose)				
	Pretest		Posttest		P Value
	Mean	SD	Mean	SD	
Temperature (Celsius)	35.3	0.3	35.7	0.4	0.0005
Pulse Rate (bpm)	76.3	12.9	105.1	16.7	0.0000
Systole	126.6	11.5	128.4	17.7	0.2819
Diastole	84.6	12.1	83.2	10.9	0.2676
Glucose Level (mg/dL)	91.6	10.3	102.3	20.7	0.0001
Running Time (seconds)	-	-	904.8	189.2	-

Table 1 shows data for body temperature for the test before (35.3±0.350C) and after (35.7±0.410C). The *p-value* of 0.0005 (p = 0.05) indicates a significant difference between before and after the test. There is an increase in body temperature after intense activities, in this case, running 2.4 kilometers. This is supported by Handayani et al. (2016), who state that increased physical activity causes an increase in body temperature, which reflexively triggers the heat dissipation mechanism. Aside from producing energy in the form of movement, energy metabolism also has power in the form of heat (Irawan, 2007).

The pulse rate before the test is 76.3±12,9 beats per minute (bpm); after the test, it is 105.1±16.7 bpm. The *p-value* is *0.0000*, showing a significant difference between before and after the test. The increase occurs due to physical activity. The heart rate will increase quickly when the subject starts running. This happens as the body's need for oxygen carried by the blood increases and causes the heart to pump blood more often (Barret et al., 2016; Maulana et al., 2020).

Blood pressure before completing the test shows the systole is 126.6±11.5 and after completing the test is 128.4±17.7 with p=0.2819, while the diastole before the test is 84.6±12.1 and after the test is 83.2±10.9 with p=0.2676. The data shows no significant difference between systole and diastole before and after completing the test. The p-value for both systole and diastole is greater than 0.05. There is no significant increase in blood pressure (systole and diastole). Based on blood pressure categories according to the American Heart Association, the average blood pressure of the subjects was classified as high blood pressure (systolic pressure: 120–129 mmHg, and diastolic pressure: <80 mmHg). Physical activity increases the heart rate. It also increases energy requirements by cells, tissues, and organs of the body, which may increase respiratory activity and vein activities, which causes an increase in stroke volume and cardiac output, thereby causing blood pressure to increase moderately (Aji, 2015).

The data also shows a change in blood sugar level between before (91.6±10.3) and after (102.3±20.7), completing the test with a p-value of 0.0001, which offers a significant difference between before and after. The mean value and standard deviation for running time for experiment one (without glucose intake) are 904.8±189.2 seconds.

Experiment Two (with glucose solution):

Table 2 shows experiment two's mean value, standard deviation, and p-value for the subjects after being given glucose solution before and after completing the Cooper test running 2.4 kilometers.

Table 2

Experiment Two with Glucose Intake

Variable	Experimental Two (Glucose Solution)				P Value
	Pretest		Posttest		
	Mean	SD	Mean	SD	
Temperature (Celsius)	35.7	0.08	36.9	0.26	0.0000
Pulse Rate (bpm)	77.2	9.04	124.1	13.7	0.0000
Systole	123.7	12.7	140.7	14.0	0.0000
Diastole	80.6	11.3	81.1	8.39	0.3955
Glucose Level (mg/dL)	85.3	9.6	-	-	-
Glucose Level (mg/dL): 30 minutes after glucose intake	140.3	16,36	-	-	0,0000
Glucose Level (mg/dL)-after the test	-	-	89.9	16.61	-
Running Time (seconds)	-	-	837.6	173.9	-

Table 2 shows data for body temperature before (35.7±0.080C) and after (36.9±0.260C) the test. The p-value of 0.0000 (p = 0.05) indicates a significant difference between before and after the test. Similar to experiment one, there is a substantial increase in body temperature due to intense physical activities, such as running 2.4 kilometers. The temperature rise is caused by energy metabolism, which produces heat, meaning if the body temperature is higher than the environmental temperature, the body will sweat. This is supported by the statement of Sandi et al. (2017) that up to 20%–30% of the heat produced by the body during exercise is made from energy burning, with the remaining heat being converted into body heat. Someone who runs needs a lot of oxygen so that the heart can pump more blood throughout the body.

The pulse rate before the test is 77.2±9.04 beats per minute (bpm); after the test, it is 124.1±13.7 bpm. The p-value is 0.0000, showing a significant difference between before and after the test. There is a substantial increase in pulse rate after the test. Physical activity affects the pulse rate. Ismail et al. (201) stated that exercise causes the heart rate to increase due to the increase in sympathetic and decrease in parasympathetic activity in the sinoatrial (SA) node. This is the body's natural response to increase heart rate and speed up the distribution of energy-producing substances (Ashadi, 2014).

Blood pressure before the test shows the systole is 123.7±12.7, and after completing the test, it is 140.7±14.0 with p = 0.0000. The data shows a significant difference in systole before and after completing the test. The p-value is less than 0.05. On the other hand, the diastole before completing the test is 80.6±11.3; after the test, it is 81.1±8.39 with p=0.3955. The data shows no significant difference in the diastole before and after completing the test because the p-value is more significant than 0.05. The data also indicates a change in blood sugar level between before (140.3±16.36) and after (89.9±16.61), completing the test with a p-value of 0.0000, which shows a significant difference between before and after. The mean value and standard deviation for running time for experiment two (after glucose intake) are 837.6±173.9 seconds. Systolic blood pressure is when the heart contracts, while diastolic blood pressure is when the heart relaxes. When exercising, systolic blood pressure generally increases due to an increase in the heart rate (the amount of blood pumped in one minute) and an increase in peripheral resistance (the resistance to blood flow in small blood vessels). Meanwhile, diastolic blood pressure tends not to change or may even decrease slightly because there is an increase in blood vessel capacity, which causes a decrease in peripheral resistance. This situation occurs because when a person exercises, the body needs more oxygen, so the heart has to work harder to pump blood. As a result, systolic blood pressure increases due to stronger heart contractions. On the other hand, diastolic blood pressure does not change or decrease because blood vessels are wide open, blood flow to body tissues is smoother, and peripheral resistance decreases.

Comparison of Pretest in Experiment One and Experiment Two (No-Glucose Intake)

Table 3 shows the mean value, standard deviation, and p-value of comparing the pretests in experiments one and two after completing the Cooper test running 2.4 kilometers.

Table 3

Pretest Comparison between Experiment One and Experiment Two (No Glucose Intake)

Variable	Pretest (No-Glucose)				
	Experiment One		Experiment Two		P Value
	Mean	SD	Mean	SD	
Temperature (Celsius)	35.3	0.3	35.7	0.1	0.0000
Pulse Rate (bpm)	76.3	12,9	77.2	9.0	0.0849
Systole	126.6	11.5	123.7	12.7	0.0447
Diastole	84.6	12.1	80.6	11.3	0.3585
Glucose Level (mg/dL)	91.6	10.3	85.3	9.6	0.0004

Table 3 shows a significant difference for body temperature (35.3±0.3, 35.7±0.08, p=0.0000), systole (126.6±11.5, 123.7±12.7, p=0.0447), and fasting blood glucose level (91.6±10.3, 85.3±9.6, p=0.0004) between experiment one and experiment two no-glucose with a p value less than 0.05. Meanwhile, the data also shows there is no significant difference for pulse rate (76.3±12,9, 77.2±9.04, p=0.0849) and diastole (84.6±12.1, 80.6±11.3, p=0.3585) between experiment one and experiment two without glucose with a p-value greater than 0.05. Pulse rate and systolic and diastolic blood pressure did not experience significant changes, as shown in Table 3, due to the absence of intense physical activities. Several factors are causing the absence of substantial changes in the subjects, such as the subjects staying in the same environment, eating the same foods, and being monitored for not doing any intense physical activities during the research.

Comparison of Posttest in Experiment One and Experiment Two (With Glucose Intake)

Table 4 shows the mean value, standard deviation, and p-value of the comparison between the posttest in experiments one and two after completing the Cooper test running 2.4 kilometers. Table 4 shows a significant difference for body temperature (35.7±0.4, 36.9±0.26, p=0.0000), pulse rate (105.1±16.7, 124.1±13.7, p=0.0000), systole (128.4±17.7, 140.7±14.0, p=0.0000), blood glucose level (102,3±20,7, 89,9±16,61, p=0.0000), and running time (904.7±189,6, 837,6±173,9, p=0.0021) between experiment one and experiment two with glucose solution. The p-value is less than 0.05. Meanwhile, a comparison between experiments one and two for diastole (83.2±10.9, 81.1±8.39, p=0.3955) shows no significant difference (p-value greater than 0.05).

Table 4

Posttest Comparison between Experiment One and Experiment Two (No Glucose Intake)

Variable	Pretest (Glucose Intake)				P Value
	Experiment One		Experiment Two		
	Mean	SD	Mean	SD	
Temperature (Celsius)	35.7	0.4	36.9	0.26	0.0000
Pulse Rate (bpm)	105.1	16.7	124.1	13.7	0.0000
Systole	128.4	17.7	140.7	14.0	0.0000
Diastole	83.2	10.9	81.1	8.39	0.3955
Glucose Level (mg/dL)	102,3	20,7	89,9	16,61	0.0000
Running Time (seconds)	904,7	189,6	837,6	173,9	0.0021

Data shows there is a significant increase in body temperature. Although the range is below normal (37,2–37,5˚C), this can still be considered normal (>35˚C). This condition is due to the temperature in Parongpong, which is between 11 oC and 22 oC. As the subjects ascend to higher altitudes, the air temperature generally decreases. This means that subjects are exposed to colder conditions, which can decrease their body temperature.

The pulse rate also significantly changes due to intense physical activities, such as running 2.4 kilometers. Pulse rate and glucose intake are related in that changes in blood glucose levels can influence heart rate, especially during certain physiological responses to food intake and exercise.

There is an increase in systolic blood pressure and a slight increase in diastolic blood pressure. This condition occurs because of glucose intake. Mansoori et al. (2019) stated that there is a strong association between the intake of added sugar and systolic and diastolic blood pressure. As mentioned above, when a subject exercises, systolic blood pressure generally increases due to an increase in the heart rate and an increase in peripheral resistance. Meanwhile, diastolic blood pressure tends not to change or may even decrease slightly because of the increase in blood vessel capacity, which causes a decrease in peripheral resistance.

There is a significant increase in blood glucose after 30 minutes of glucose solution intake. High blood glucose levels may trigger the release of insulin, which directs glucose into the body's cells to be used as an energy source.

Data shows running time decreasing in experiment two after the glucose solution was given. This means the subjects ran faster and had less travel time than in experiment 1, without a glucose solution. This condition is due to the high availability of energy sources needed for running. This study shows that giving a glucose solution before starting exercise affects physical performance. The results align with the study by Budi (2010), which stated that giving fructose and glucose could speed up the travel time of 3000-meter runners.

Comparison of VO2 Max Between Experiment One and Experiment Two

Data shows that in experiment one with no-glucose intake, of the total of 30 subjects, no one was categorized as "excellent" (0%) or "very good" (0%, only one subject was categorized as "good" (3.3%). Eight subjects categorized as "moderate" (26.7%), fourteen as "poor' (46.7%), and seven as "very poor" (23.3%). Meanwhile, in experiment two with glucose intake, none of the 30 subjects categorized as "excellent" (0%) nor as "very good" (0%). Seven subjects are categorized as "good" (23.3%), seven subjects categorized as "moderate" (23.3%), ten subjects categorized as "poor" (33.3%), and six classified as "very poor" (20%).

Table 5

Comparison of VO2 Max Between Experiment One and Experiment Two

Category	Experiment One (No-Glucose Intake)		Experiment Two (Glucose Intake)	
	Absolute	Percent (%)	Absolute	Percent (%)
Excellent	0	0	0	0
Very Good	0	0	0	0
Good	1	3.3	7	23.3
Moderate	8	26.7	7	23.3
Poor	14	46.7	10	33.3
Very Poor	7	23.3	6	20
Total	30	100	30	100

VO2 max measures a person's ability to use oxygen during maximal physical activity. VO2 max results can vary depending on many factors that can vary between individuals, including genetics, environmental factors, and a person's level of physical fitness (Myers, 2022). There was an increase in the VO2 max category of each subject, possibly because an additional energy source was provided to provide enough energy for running, which would help increase strength and endurance. The relationship between endurance and VO2 max is that the higher a person's VO2 max, the more efficient their body is at using oxygen during exercise, thus allowing a person to carry out physical activity for a longer period of time. In other words, the higher the VO2 max, the higher a person's endurance ability in exercise with higher intensity.

Based on the results on the effect of glucose intake on the physical performance of non-athlete students using the Cooper 2.4 kilometers running test method, this study concluded that glucose administration has an effect on the physical performance of non-athlete students by decreasing running time. Further study is needed regarding administering glucose to more sample subjects.

It is recommended that research on female non-athlete students be conducted to find out whether there is an effect of giving a glucose solution on physical performance and increasing travel time while still paying attention to the menstrual cycle, such as its duration and intensity as well as the peaks of the hormones progesterone and estrogen.

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