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ACUTE BLOOD GLUCOSE RESPONSES TO RESISTANCE VERSUS AEROBIC EXERCISE IN PHYSICALLY ACTIVE STUDENTS

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ABSTRACT

This study investigated the acute effects of aerobic and resistance exercises on blood glucose levels in physically active students, with an additional focus on the transient impact of chewing sugar-free gum. A total of 30 male participants aged 20–26 years from Pondicherry University were divided into three groups: Experimental Group 1 (aerobic exercise via the Cooper 12-minute run/walk test), Experimental Group 2 (resistance training via a muscular fitness test), and a Control Group (no exercise). Blood glucose levels were measured under three conditions: before warm-up (baseline), after 10 minutes of chewing sugar-free gum (pre-test), and 15 minutes post-exercise (post-test). Data were analysed using a one-way ANOVA and Scheffe post-hoc test, with significance at $p < 0.05$. Results revealed significant reductions in blood glucose levels after chewing gum in all groups ($p < 0.05$), suggesting a transient glucose-lowering effect. Post-exercise, Group 1 (aerobic) showed a significant decrease in blood glucose ($p = 0.005$), while Group 2 (resistance) exhibited a transient increase ($p = 0.000$), likely due to anaerobic metabolic demands. The Control Group demonstrated no significant change between pre-and post-test conditions ($p = 0.309$), highlighting the role of physical activity in glucose regulation. The findings indicate that aerobic and resistance exercises effectively regulate blood glucose levels, albeit through different mechanisms. Aerobic exercise demonstrated a more consistent glucose-lowering effect, while resistance training showed greater variability. Chewing sugar-free gum emerged as a potential adjunct to exercise for transient glucose management. These results underscore the importance of tailored exercise prescriptions for metabolic health and suggest further exploring non-invasive interventions like chewing gum in glucose regulation strategies.

KEYWORDS: *Blood glucose, aerobic exercise, resistance training, chewing gum, metabolic health, physical activity.*

INTRODUCTION

In contemporary society, the pursuit of optimal health and well-being has become a paramount concern, encompassing physical, mental, and emotional dimensions. Central to physical health is the regulation of blood glucose levels, a critical factor in maintaining energy balance and preventing chronic diseases such as diabetes. Blood glucose, derived from dietary intake, serves as the primary energy source for cellular functions. However, when levels exceed normal thresholds, it can lead to detrimental health outcomes, underscoring the importance of maintaining fasting glucose levels between 70-100 mg/dL and postprandial levels below 140 mg/dL (Blood Glucose, n.d.).

Physical fitness, a multifaceted concept, is integral to overall health. Defined as the ability to perform daily tasks with vigour and without undue fatigue, physical fitness encompasses cardiovascular efficiency, muscular strength, flexibility, and endurance (CDC, 2016; Caspersen et al., 1985). The modern emphasis on cardiovascular fitness has grown in response to the rising prevalence of cardiac disorders, driven by sedentary lifestyles and increased stress (Singh, 2003). Regular physical activity not only enhances muscular and cardiorespiratory fitness but also mitigates stress, anxiety, and depression, thereby improving overall quality of life (USDHHS, 2008; Gonzalez, 2017).

Resistance training, a key component of physical fitness, has evolved significantly since its early documentation in ancient Greece. It impacts multiple body systems, including muscular, skeletal, and metabolic systems, and is essential for improving strength, power, and endurance (Deschenes & Kraemer, 2002; Zatsiorsky, 1995). Concurrently, aerobic exercise, characterized by sustained moderate-intensity activities, enhances cardiovascular health, oxygen utilization, and metabolic efficiency (Tanaka and Swensen, 1998). The integration of both resistance and aerobic training has been shown to optimize physical performance and health outcomes, particularly in endurance athletes (Bishop and Jenkins, 1999).

Beyond traditional exercise, emerging research highlights chewing gum's cognitive and dental health benefits, particularly sugar-free varieties sweetened with xylitol. Chewing gum has been associated with improved working memory, episodic memory, and perceptual speed, although the mechanisms

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remain under investigation (Onyper et al., 2011). Additionally, xylitol-based gums have demonstrated efficacy in reducing dental cavities and plaque, offering a simple yet effective adjunct to oral hygiene practices.

This paper seeks to explore the interplay between physical fitness, blood glucose regulation, and the potential cognitive and dental health benefits of chewing gum. By synthesising existing literature, we aim to comprehensively understand how these factors collectively contribute to overall health and well-being, offering insights for future research and practical applications in health promotion and disease prevention.

METHODOLOGY

Selection of Subjects

To facilitate the study, a total of 30 male players aged between 20 and 26 years were selected from Pondicherry University. To ensure homogeneity and minimize variability among participants, a 1-mile run/walk test was conducted as part of the TID Talent Identification Testing Program. Subjects who completed the test within 325 to 340 seconds were included in the study. Most of the participants were from the Physical Education department, while others were recruited from various departments across the university. All participants were thoroughly informed about the study's objectives, procedures, and potential risks, and written consent was obtained prior to participation.

Participants were excluded if they reported any recent injuries, musculoskeletal pain, neurological conditions, or other disorders that could impair their ability to perform the required exercises. Additionally, individuals with pre-existing limitations, such as chronic back pain or lower extremity injuries, were excluded to ensure the safety and validity of the study.

The selected subjects were then categorized into two experimental groups and one control group:

- **Experimental Group 1 (EG1):** 10 participants were assigned to the Cooper 12-minute run/walk test (aerobic/endurance exercise).
- **Experimental Group 2 (EG2):** 10 participants were assigned to the Strength/Resistance Muscular Fitness Test.
- **Control Group (CG):** 10 participants who did not perform any exercise.

Selection of Variables

The primary variable selected for this study was blood glucose level, a critical indicator of metabolic health and exercise-induced physiological responses. This variable was selected based on a comprehensive review of scientific literature, expert consultations, and the feasibility of measurement using available equipment.

Research Design

A comparative research design was employed to evaluate the effects of aerobic and resistance exercises on blood glucose levels. The study involved pre-test and post-test measurements of blood glucose levels under three conditions:

1. **Before warm-up (Condition 1):** Baseline blood glucose measurement.
2. **Pre-test (Condition 2):** Blood glucose measurement after 10 minutes of chewing sugar-free gum.
3. **Post-test (Condition 3):** Blood glucose measurement after completing the assigned exercise protocol.

Selection of Test Tools

Blood glucose levels were measured using the Dr. Morepen GlucoOne Blood Glucose Monitoring System (Model Code: BG-03), which employs biosensor technology. The device has the following specifications:

- **Test Range:** 20–600 mg/dL
- **Sample Volume:** 0.5 µL of capillary whole blood
- **Test Time:** 5 seconds
- **Memory:** Stores up to 300 results
- **Hematocrit Range:** 35–50%
- **Power Source:** 3V Lithium Battery (CR2032)
- **Weight:** 45 g (including battery)
- **Storage Conditions:** 39.2–88°F (4–30°C)
- **Operating Conditions:** 50–104°F (10–40°C)
- **Test Strips:** Code A11 Auto (BG-03)

DATA COLLECTION PROCEDURE

Warm-Up Protocol

All participants performed a standardized warm-up routine consisting of light jogging and dynamic movements to prepare their bodies for the subsequent exercise tests. After the warm-up, a 5-minute recovery period was provided to ensure participants were in a stable physiological state before testing.

Testing Protocol

The study was conducted in two phases:

Phase 1 (Day 1)

- **Experimental Group 1 (EG1):** Performed the Cooper 12-minute run/walk test as a standard aerobic/endurance exercise.
- **Control Group (CG):** Did not perform any exercise.

Phase 2 (Day 2)

- **Experimental Group 2 (EG2):** Performed the Strength/Resistance Muscular Fitness Test.
- **Control Group (CG):** Did not perform any exercise.

Blood Glucose Measurement Conditions

1. **Before Warm-Up (Condition 1):** Baseline blood glucose levels were measured while participants were seated.
2. **Pre-Test (Condition 2):** Participants chewed sugar-free gum for 10 minutes, after which blood glucose levels were measured.
3. **Post-Test (Condition 3):** Participants completed their assigned exercise protocol, followed by a 1-minute cool-down period. Blood glucose levels were measured 15 minutes after exercise completion.

Exercise Protocols

Cooper 12-Minute Run/Walk Test (EG1):

1. Participants warmed up with light jogging and dynamic movements.

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2. A 400-meter track and a stopwatch recorded the start and end times.
3. Participants were instructed to cover as much distance as possible in 12 minutes.
4. Walking was encouraged during the cool-down period.

Strength/Resistance Muscular Fitness Test (EG2):

1. **Hip Flexo-Extensions (Sit-Ups):** Measures the strength and endurance of abdominal muscles.
2. **Push-Ups:** Measures the strength and endurance of elbow extensors.
3. **Deep Squats:** Measures the strength and endurance of knee and hip extensors.
4. **Burpees:** Measures the coordinated strength and endurance of multiple muscle groups (abdominals, back, chest, arms, and legs).

Description of Tools

- **Cooper 12-Minute Run/Walk Test:** 400-meter track, stopwatch, performance recording sheet.
- **Muscular Fitness Test:** Yoga mat, hard surface, stopwatch, performance recording sheet.

Data Collection

The investigator collected data through direct administration of the Cooper 12-minute run/walk test and the Muscular Fitness Test. Clear instructions were provided to participants to ensure proper execution of the exercises. Blood glucose measurements were taken at the specified intervals using the Dr. Morepen GlucoOne device.

ANALYSIS OF DATA AND RESULTS OF THE STUDY

27 subjects were selected to facilitate the study. The subjects are from Pondicherry University, where several departments were selected, mainly in the physical education field. The result is analysed through ONEWAY ANOVA TEST and POST-HOC TEST The level of significance was fixed at 0.05.

Table 1: One-Way ANOVA

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Group 1 (Aerobic/Cooper 12minute run/walk)	Between Groups	1667.704	2	833.852	6.991	.002
	Within Groups	6082.611	51	119.267		
	Total	7750.315	53			
Group 2 (Strength-Resistance Muscle Fitness test	Between Groups	4862.926	2	2431.463	24.220	.000
	Within Groups	5119.833	51	100.389		
	Total	9982.759	53			
Group 3 (Control Group)	Between Groups	1643.815	2	821.907	14.090	.000
	Within Groups	2975.000	51	58.333		
	Total	4618.815	53			

The significance level was fixed at 0.05

Experimental groups, as well as Control groups, show significant differences between groups.

Group 1 (F=6.991 [p=0.002]), Group 2 (F=24.220[p=0.000]), Group 3 (F=14.090[p=0.000]).

Table 2: Scheffe Post-Hoc Test

Multiple Comparisons

Scheffe

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Group 1 (Aerobic/Cooper 12minute run/walk)	1.00	2.00	-11.00000*	3.64031	.015	-20.1788	-1.8212
		3.00	1.44444	3.64031	.924	-7.7343	10.6232
	2.00	1.00	11.00000*	3.64031	.015	1.8212	20.1788
		3.00	12.44444*	3.64031	.005	3.2657	21.6232
	3.00	1.00	-1.44444	3.64031	.924	-10.6232	7.7343
		2.00	-12.44444*	3.64031	.005	-21.6232	-3.2657
Group 2 (Strength-Resistance Muscle Fitness test	1.00	2.00	-10.72222*	3.33981	.009	-19.1433	-2.3011
		3.00	12.50000*	3.33981	.002	4.0789	20.9211
	2.00	1.00	10.72222*	3.33981	.009	2.3011	19.1433
		3.00	23.22222*	3.33981	.000	14.8011	31.6433
	3.00	1.00	-12.50000*	3.33981	.002	-20.9211	-4.0789
		2.00	-23.22222*	3.33981	.000	-31.6433	-14.8011
Group 3 (Control Group)	1.00	2.00	-9.22222*	2.54588	.003	-15.6415	-2.8030
		3.00	-13.16667*	2.54588	.000	-19.5859	-6.7474
	2.00	1.00	9.22222*	2.54588	.003	2.8030	15.6415
		3.00	-3.94444	2.54588	.309	-10.3637	2.4748
	3.00	1.00	13.16667*	2.54588	.000	6.7474	19.5859
		2.00	3.94444	2.54588	.309	-2.4748	10.3637

*. The mean difference is significant at the 0.05 level.

The significance level was fixed at 0.05

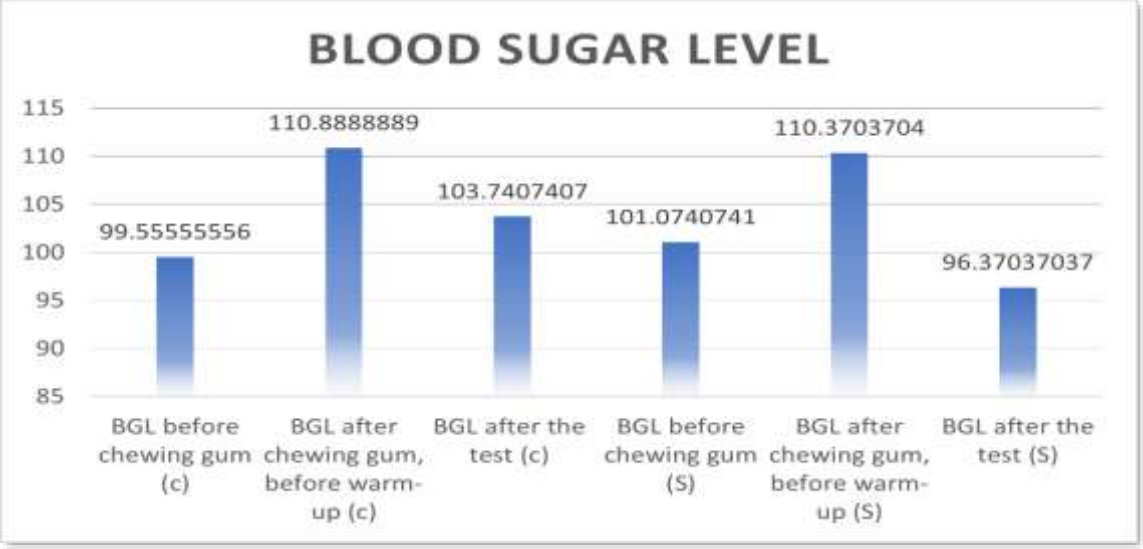
The pre-test (2.00) and post-test (3.00) of the experimental group (group 1 and group 2) show significant differences, whereas group 3 has no significant difference. (group1 p=0.005, MD=12.44, group2 p=0.000, MD=23.22, group3 p=0.309, MD=-3.944).

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This shows Group 2 (strength,) has a higher significant value than Group 1 (Aerobic) and Group 3 (control group)

BAR DIAGRAM SHOWING AVERAGE BLOOD SUGAR LEVEL

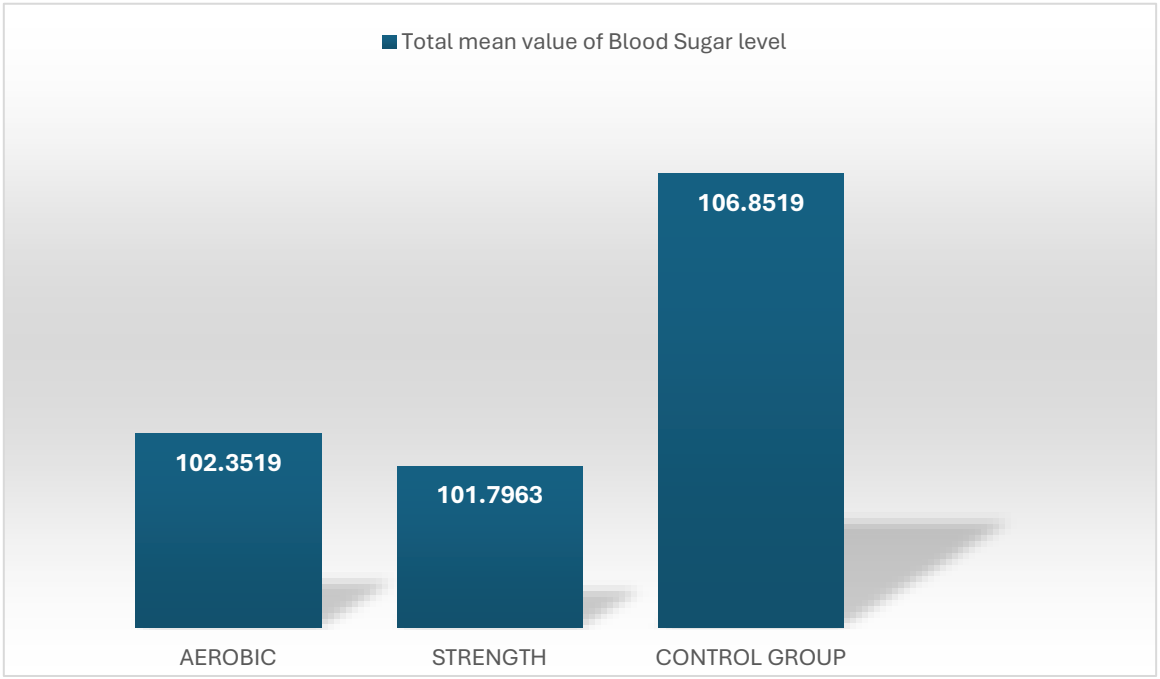
- **C= COOPER/AEROBIC TEST**



- **S= STRENGTH-RESISTANCE MUSCLE FITNESS TEST**

BAR DIAGRAM SHOWING THE DIFFERENCE IN BLOOD SUGAR LEVEL

Figure 1



The total mean value of the three groups included BGL before chewing gum (1.00), BGL after chewing gum before warmup (2.00), and BGL after the test (3.00).

BGL= BLOOD SUGAR LEVEL

DISCUSSION

The present study investigated the effects of aerobic and resistance exercises on blood glucose levels, specifically comparing the responses of participants in experimental groups (aerobic and resistance training) to those in a control group (no exercise). The findings reveal significant variations in blood glucose levels across the three conditions (before warm-up, pre-

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test after chewing gum, and post-test after exercise) for each group and notable differences between the groups. These results provide valuable insights into the role of physical activity and chewing gum in modulating blood glucose levels, which has implications for metabolic health and exercise prescription.

Group 1 (Aerobic/Cooper 12-Minute Run/Walk Test)
The mean blood glucose levels for Group 1 ranged from 97.72 mg/dL to 110.17 mg/dL across the three conditions, with a total mean of 102.35 mg/dL. The significant differences observed between conditions highlight the impact of aerobic exercise on blood glucose regulation.

- Condition 1.00 vs. Condition 2.00: A significant decrease in mean blood glucose levels was observed after participants chewed sugar-free gum for 10 minutes ($p = 0.015$). This finding aligns with previous studies suggesting that chewing gum can transiently enhance insulin sensitivity and glucose uptake, potentially due to increased salivary flow and parasympathetic activity (Onyper et al., 2011).
- Condition 2.00 vs. Condition 3.00: A further significant reduction in blood glucose levels was noted after the completion of the Cooper 12-minute run/walk test ($p = 0.005$). This is consistent with existing literature, which indicates that aerobic exercise enhances glucose utilization by skeletal muscles, thereby lowering blood glucose levels (Tanaka & Swensen, 1998).

These findings underscore the efficacy of aerobic exercise in managing blood glucose levels, particularly in individuals engaged in moderate-intensity endurance activities. The results also suggest that chewing gum may serve as a simple, non-invasive adjunct to exercise for improving glucose metabolism.

Group 2 (Strength/Resistance Muscular Fitness Test)
Group 2 exhibited a wider range of blood glucose levels, with means varying from 89.89 mg/dL to 113.11 mg/dL and a total mean of 101.80 mg/dL. The higher variability in this group, particularly in Condition 2.00, may be attributed to the diverse physiological responses elicited by resistance training.

- Condition 1.00 vs. Condition 2.00: A significant reduction in blood glucose levels was observed after chewing gum ($p = 0.009$), similar to Group 1. This reinforces the potential role of chewing gum in transiently modulating glucose metabolism.
- Condition 2.00 vs. Condition 3.00: A highly significant increase in blood glucose levels was noted post-exercise ($p = 0.000$). This contrasts with the aerobic group and may be explained by the anaerobic nature of resistance training, which can transiently elevate blood glucose due to glycogenolysis and gluconeogenesis (Bishop & Jenkins, 1999).

The findings suggest that while resistance training is effective in improving muscular fitness, its impact on blood glucose regulation may differ from that of aerobic exercise, particularly in the immediate post-exercise period. This highlights the need for tailored exercise prescriptions based on individual health goals and metabolic responses.

Group 3 (Control Group)
The control group, which did not engage in any exercise, displayed mean blood glucose levels ranging from 99.39 mg/dL to 112.56 mg/dL, with a total mean of 106.85 mg/dL. This group served as a baseline for comparison with the experimental groups.

- Condition 1.00 vs. Condition 2.00: A significant decrease in blood glucose levels was observed after chewing gum ($p = 0.003$), consistent with the trends in the experimental groups. This further supports the hypothesis that chewing gum may have a transient glucose-lowering effect, independent of exercise.
- Condition 1.00 vs. Condition 3.00: A highly significant reduction in blood glucose levels was noted in the post-test condition ($p = 0.000$), likely due to the natural decline in glucose levels over time in the absence of food intake.
- Condition 2.00 vs. Condition 3.00: No significant difference was observed ($p = 0.309$), indicating that chewing gum alone did not have a sustained effect on blood glucose levels in the absence of physical activity.

These results highlight the importance of physical activity in maintaining optimal blood glucose levels, as the control group exhibited higher mean glucose levels compared to the experimental groups.
Comparative Analysis of Groups

- Total Mean Values: The total mean blood glucose levels were similar for Group 1 (102.35 mg/dL) and Group 2 (101.80 mg/dL), both of which were lower than the control group (106.85 mg/dL). This suggests that both aerobic and resistance exercises are effective in regulating blood glucose levels, albeit through different mechanisms.
- Variability: Group 2 exhibited the highest variability, particularly in Condition 2.00, which may reflect the diverse metabolic demands of resistance training compared to the more uniform responses elicited by aerobic exercise.
- Range of Data: The wider range of blood glucose levels in Group 2 further underscores the heterogeneous nature of resistance training's impact on glucose metabolism.

Implications of Findings

1. Aerobic Exercise: The significant reduction in blood glucose levels post-exercise in Group 1 highlights the role of aerobic activities in enhancing glucose uptake and utilization. This supports the inclusion of moderate-intensity aerobic exercises in lifestyle interventions for individuals with or at risk of metabolic disorders (Singh, 2003).
2. Resistance Training: While resistance training also demonstrated glucose-lowering effects, the transient increase in blood glucose levels post-exercise suggests that its metabolic impact may differ from aerobic exercise. This underscores the need for tailored

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exercise prescriptions based on individual health goals (Zatsiorsky, 1995).

3. Chewing Gum: The transient glucose-lowering effect observed after chewing gum across all groups warrants further investigation. It may have potential applications as a simple, non-invasive adjunct to exercise for managing blood glucose levels (Onyper et al., 2011).

CONCLUSION

The study demonstrates that both aerobic and resistance exercises are effective in regulating blood glucose levels, with aerobic exercise showing a more consistent glucose-lowering effect. The transient impact of chewing gum on blood glucose levels presents an intriguing area for further research. These findings contribute to the growing body of evidence supporting the role of physical activity in metabolic health and highlight the potential benefits of integrating simple interventions, such as chewing gum, into exercise regimens.

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