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Drink More, Risk Less: How Hydration Shapes Diabetes Risk in Saudi Arabia

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Abstract
Diabetes mellitus is an escalating public health issue in Saudi Arabia, with rising prevalence linked to lifestyle factors such as nutrition, physical activity, and hydration practices. This study investigates the relationship between water drinking habits and diabetes risk among adults in Riyadh Province, where severe climatic circumstances may intensify hydration-related health concerns. A longitudinal study approach was employed to track 300 people aged 30 to 65 over a two-year period, collecting data on water consumption, glycemic indicators, and related health behaviors. The results demonstrate that persons consuming ≥2 liters of water daily had reduced fasting blood glucose (94 mg/dL) and HbA1c levels (5.6%) in contrast to those consuming <2 liters daily (102 mg/dL and 6.1%, respectively). Moreover, insufficient hydration was markedly associated with a higher incidence of prediabetes and diabetes. Rural participants, characterized by diminished water consumption and limited access to purified water, demonstrated poorer glycemic results. The research highlights the significance of sufficient hydration in the prevention and control of diabetes, especially in arid conditions. Public health campaigns must incorporate hydration education with traditional diabetes prevention techniques to reduce risks and enhance metabolic health in Saudi Arabia.

Highlight
- *Low water intake (<2L/day) significantly increases diabetes risk, highlighting the importance of hydration in glycemic management.*
- *Rural individuals use less water and rely more on untreated sources, which may raise diabetes and metabolic health disparities.*
- *Daily hydration guidelines enhance fasting glucose and HbA1c levels, suggesting that diabetes prevention can be simple and inexpensive.*
- *Hydration, diet, and exercise interact, highlighting the need for a holistic diabetes management strategy, especially in desert countries like Saudi Arabia.*
- *This study urges public health strategies to include hydration awareness in national diabetes prevention campaigns, concentrating on water quality and intake.*
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Introduction
Chronic disorders, such as diabetes mellitus (DM), are on the rise globally, and Saudi Arabia is no exception. The Saudi Ministry of Health said that more than 4 million people in Saudi Arabia were living with diabetes in 2019, bringing the prevalence of the disease to an estimated 18.3%. Changes in lifestyle, such as eating poorly and not getting enough exercise, are likely to contribute to this rising tide (Saudi Ministry of Health, 2019). Obesity, a diet heavy in

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calories, and other environmental variables that discourage a healthy lifestyle are common risk factors for type 2 diabetes mellitus (T2DM), the most common kind of adult diabetes.

Patterns of water consumption are starting to get some attention in the prevention and management of diabetes. Hydration positively affects glucose control, metabolic rate, and renal function, according to previous studies (Popkin et al., 2010). The body's primary component, water, aids in the metabolism of carbohydrates and helps regulate blood sugar levels. It also helps to keep the body's fluid equilibrium. However, there has been a lack of thorough study into the association between water consumption patterns and the onset of diabetes mellitus in adults, particularly in the setting of long-term studies. For this reason, it is critical to conduct additional studies to clarify the function of water in diabetes prevention and treatment.

Riyadh Province, Saudi Arabia, is home to a diverse population and a high diabetes prevalence, making it an ideal location for this study. With over 8 million inhabitants, Riyadh Province is home to both urban and rural regions, each with its own unique water consumption patterns and healthcare infrastructure. According to the Riyadh Regional Health Directorate, 22.5% of adults had diabetes in 2021. This number is projected to rise due to unhealthy lifestyle trends and the difficulties posed by severe heat (Riyadh Regional Health Directorate, 2021). Some regions experience especially hot summers, making it difficult to stay properly hydrated and sometimes exacerbating preexisting population health issues like diabetes.

The research area was selected as Riyadh Province due to the high incidence of diabetes that need further intervention and the fact that different demographic groups have varying water consumption patterns. This study is expected to shed light on the relationship between water consumption patterns and the development of diabetes mellitus in adults, which is important since inadequate hydration, particularly in the harsh desert climate, might exacerbate the community's health situation. The purpose of this research is to determine, within the specific cultural and climatic setting of Saudi Arabia, if sufficient water intake can aid in the management of preexisting diabetes and the prevention of type 2 diabetes mellitus.

This project aims to use a longitudinal study approach to give strong scientific evidence about the need of drinking enough water to avoid diabetes in hot and dry climates. This research will help improve Saudi Arabia's health policies and promote more focused community education programs about the importance of staying properly hydrated to prevent diabetes mellitus. This is especially important because staying properly hydrated in a desert climate can be challenging.

Methodology

This study examines the correlation between adults' water drinking habits and the onset of type 2 diabetes mellitus using a quantitative methodology and a longitudinal study design. The water consumption habits of urban and rural areas in Riyadh Province, Saudi Arabia, varied significantly, which led to its selection as the research location. The subjects were monitored frequently every six months for the course of the two-year trial (January 2023–December 2024).

Individuals residing in Riyadh Province who fall between the age bracket of 30–65 make up the research population. To guarantee a balanced representation of respondents from both urban and rural locations, a stratified random selection approach was used to choose 300 persons for the research sample. A significance level of 5% and a statistical power of 80% were considered when the sample was taken.

People who were willing to take part in the study for the whole two years, were not pregnant or nursing, and did not have any other serious chronic conditions were considered to

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be part of the sample. To ensure the data is reliable, we did not include those who had kidney failure or cancer, both of which might impact metabolism.

Finding

Demographic and health status profile of study participants in riyadh province

A total of 300 people, ranging in age from 30 to 65, were chosen at random from both urban and rural parts of Riyadh Province to participate in this study. In contrast to 60% who were born in urban centers, 40% were from more rural locations. With 48% men and 52% women among the responders, the gender distribution was almost even. Table 1 summarizes the demographic data broken down by age group, gender, and region of residence.

Table 1. Age Distribution of Respondents

Characteristic	Number of Respondents	Percentage (%)
Age (year)		
30–39	45	15%
40–49	105	35%
50–59	90	30%
60–65	60	20%
Gender		
Male	144	48%
Female	156	52%
Area of Residence		
Urban	180	60%
Rural	120	40%

Many of the responders were dealing with health problems of some kind. Consistent with the alarmingly high obesity rates in Saudi Arabia, the majority of people were overweight or obese, as shown by the average body mass index (BMI) of 26.2 kg/m². With a mean BP of 130/85 mmHg, hypertension affected almost 35% of the participants. Fasting blood glucose levels above 100 mg/dL were detected in 22% of patients, and HbA1c levels above 6.5% in 18%, suggesting type 2 diabetes, in the initial blood glucose testing. The body mass index (BMI), blood pressure, glucose, and other vital signs are detailed in Table 2.

Table 2. Respondents' Baseline Health Status

Parameter	Category	Number of Respondents	Percentage (%)
Body Mass Index (BMI)	Normal (18.5–24.9 kg/m²)	90	30%
	Overweight (25–29.9 kg/m²)	135	45%
	Obesity (≥30 kg/m²)	75	25%
Blood Pressure	Normal (<120/80 mmHg)	195	65%
	Hypertension (≥130/85 mmHg)	105	35%
Fasting Blood Glucose (FBG)	Normal (<100 mg/dl)	234	78%
	Prediabetes (100–125 mg/dl)	42	14%
	Diabetes (>126 mg/dl)	24	8%
HbA1c	Normal (<5.7%)	246	82%
	Prediabetes (5.7–6.4%)	30	10%

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	Diabetes (≥6.5%)	24	8%

In line with modern Saudi society's eating habits, just 40% of respondents said they got the necessary 150 minutes of exercise each week, while 55% said they usually ate foods that were heavy in sugar and fat. Given the difficulties of staying adequately hydrated in the hot and dry climate of Saudi Arabia, it is crucial to understand the baseline health issues that may impact water consumption patterns and the risk of diabetes in this context.

Water consumption patterns in riyadh province

People living in Riyadh Province use water in very different ways, according to this research. In the hot heat of Saudi Arabia, adults should drink at least two to three liters of water daily, yet respondents only drank about 1.8 liters on average. The gap between city dwellers and those living in rural areas was wide. The average daily water consumption of urban respondents was 2 liters, while the average daily consumption of rural respondents was just 1.5 liters. Disparities in health awareness and access to clean water infrastructure may account for this discrepancy. Among the samples, the main water sources differed considerably. Rural areas' 60% reliance on well or groundwater sources raises concerns about their reliability and quality, in contrast to the 75% urban population that relies on piped municipal water. Also, there was a significant difference in the ways in which urban and rural residents prepared their water before consuming it. Seventy percent of urbanites filtered or boiled their water before use, whereas only forty percent of rural residents did so.

It was also considered how often the water was used. Water consumption was spread out throughout the day, particularly between meals, by respondents who met or exceeded the daily recommended requirement. People who drink less water often drink sugary beverages, tea, or coffee instead, which may raise metabolic risk factors associated with diabetes. This trend was worrisome because of the high temperatures and growing need for water in the area. These results are summarized in Table 3.

Table 3. Water Consumption Patterns among Respondents

Parameter	Urban Respondents (n=180)	Rural Respondents (n=120)	Total (n=300)
Average Daily Water Intake (liters)	2.0	1.5	1.8
Meeting Recommended Intake (%)	55%	30%	45%
Primary Water Source			
- Piped Municipal Water	75%	30%	57%
- Well/Groundwater	25%	60%	40%
- Bottled Water	10%	10%	10%
Water Treatment Practice			
- Treated Water (%)	70%	40%	58%
- Untreated Water (%)	30%	60%	42%

The findings underscore notable disparities in water consumption and water source quality between urban and rural populations in Riyadh Province, potentially affecting diabetes risk and

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overall health outcomes, especially given the difficulties of sustaining adequate hydration in Saudi Arabia's arid climate.

Analysis & Discussion

Relationship Between Water Consumption Patterns and Diabetes in Saudi Arabia

This study's results indicated a substantial correlation between water consumption patterns and diabetes-related indicators among people of Riyadh Province. Individuals who ingested ≥2 liters of water daily exhibited superior glycemic profiles, characterized by lower mean fasting blood glucose (FBG) levels (94 mg/dL) and hemoglobin A1c (HbA1c) levels (5.6%) in contrast to those consuming <2 liters/day, who recorded higher averages of 102 mg/dL and 6.1%, respectively.

The incidence of prediabetes and diabetes was significantly elevated among individuals with insufficient water consumption. Among individuals consuming less than 2 liters daily, 30% were classified as prediabetic or diabetic, in contrast to merely 15% of those who consumed an acceptable amount of water. A logistic regression analysis, accounting for food, physical activity, and BMI, established that inadequate water intake was independently and strongly correlated with increased HbA1c levels.

Subsequent study indicated that responders utilizing untreated water sources, especially wells or groundwater prevalent in rural regions, demonstrated a greater incidence of aberrant glycemic indicators. This discovery indicates that both the quality and quantity of water significantly influence metabolic health outcomes.

Table 4. Relationship Between Water Intake and Diabetes Markers

Water Intake Category	FBG (mg/dL)	HbA1c (%)	Prediabetic/Diabetic Proportion (%)
Adequate Intake (≥2 L/day)	94	5.6	15%
Inadequate Intake (<2 L/day)	102	6.1	30%

The findings indicate that sufficient daily water intake may confer a preventive effect against the onset of diabetes by aiding in the maintenance of normal blood glucose levels. This study's findings on the correlation between hydration state and glycemic control are consistent with recent research indicating that adequate hydration affects glucose metabolism and insulin sensitivity (Roussel et al., 2011; Carroll et al., 2016).

The discrepancies in water consumption patterns between urban and rural populations in Riyadh Province underscore significant socioeconomic and infrastructural gaps that may exacerbate health inequalities. Restricted access to clean, treated water in rural regions may constitute an overlooked risk factor for diabetes in these populations, aligning with other studies on environmental determinants of diabetes risk (Bowe et al., 2018).

The pronounced correlation between water consumption and glycemic indicators in this Saudi Arabian demographic may be partially attributed to the region's hot, arid climate, which elevates fluid needs and potentially exacerbates the metabolic consequences of chronic mild dehydration (Correa-Rotter et al., 2019). This conclusion is particularly significant as roughly 55% of respondents did not satisfy daily water intake guidelines, with the shortfall being more evident in rural regions.

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The findings indicate troubling trends of replacing water with sugar-sweetened beverages, especially among individuals with reduced water consumption. This substitution may exacerbate the adverse metabolic consequences of insufficient hydration, establishing a twofold mechanism for heightened diabetes risk (Hu & Malik, 2010; O'Connor et al., 2015).

The findings have significant implications for public health strategies in Saudi Arabia, indicating that enhancing hydration through improved water infrastructure, education on proper hydration practices, and policies concerning water quality and quantity should be incorporated into diabetes prevention initiatives (Johnson et al., 2016). The straightforward and economical measure of augmenting water consumption may substantially enhance metabolic health in this demographic, especially regarding Saudi Arabia's National Transformation Program 2020 and Vision 2030 programs (Robert et al., 2017).

Future longitudinal studies are required to ascertain causality and evaluate if interventions aimed at increasing water intake can effectively diminish diabetes incidence or enhance glycemic control in individuals with pre-existing diabetes within the Saudi Arabian environment (Al-Rubeaan et al., 2015).

Key Factors Influencing Diabetes Risk In Saudi Arabia

The research discovered multiple significant factors affecting diabetes risk among inhabitants of Riyadh Province, Saudi Arabia. The study identified water consumption patterns as a key contributor, while also emphasizing the crucial influences of BMI, dietary habits, physical activity levels, and water quality on diabetes risk profiles.

Insufficient hydration was identified as an independent risk factor, with participants consuming less than 2 liters of water daily demonstrating a 1.8-fold increased risk of elevated HbA1c values relative to those with sufficient intake. This link remained significant after controlling for potential confounding variables, indicating an independent influence of hydration state on glucose regulatory systems.

Body mass index emerged as a significant predictor of prediabetes and diabetes within this cohort. Among obese patients, 40% had elevated HbA1c levels, whereas only 10% of people with a normal BMI did. This discovery is especially pertinent in the Saudi Arabian context, where swift urbanization and evolving eating habits have led to a significant increase in obesity rates in recent decades.

Dietary habits significantly affected glycemic profiles. Participants indicating elevated intake of sugary drinks, refined carbs, and fatty foods exhibited a markedly increased risk of abnormal fasting blood glucose levels. In contrast, individuals following diets abundant in fiber, vegetables, and minimally processed foods demonstrated more advantageous glycemic profiles, highlighting the need of nutrition education in diabetes preventive initiatives.

Physical activity has proven to be an essential protective element. Participants who engaged in moderate-to-vigorous physical exercise (≥150 minutes per week) exhibited lower HbA1c levels than their sedentary peers. Regular exercise seemingly alleviated the adverse consequences of insufficient water intake, indicating a possible link between hydration levels and physical activity in glucose management.

Water quality, especially in rural regions, has been an undervalued determinant of diabetes risk. Participants utilizing untreated water from wells or groundwater sources exhibited a

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heightened probability of aberrant glycemic indicators, maybe attributable to pollutants or irregular hydration patterns linked to inadequate access to clean water infrastructure.

The intricate relationship among lifestyle choices, hydration habits, and environmental factors underscores the diverse aspects of diabetes risk in Saudi Arabia. The findings indicate that effective diabetes preventive initiatives must consider both individual behavioral habits and systemic variables, including access to clean water, public recreational facilities, and nutrition education.

Table 5. Key Factors and Their Influence on Diabetes Risk

Factor	Risk Influence
Water Intake (<2 L/day)	1.8x higher risk of elevated HbA1c
Body Mass Index (BMI)	Higher prevalence in overweight/obese groups
Dietary Habits	High-sugar/fat diets increase glycemic risk
Physical Activity	Reduces risk; mitigates hydration effects
Water Quality	Untreated water linked to higher HbA1c

The findings have significant implications for public health policy in Saudi Arabia, especially as the nation undergoes fast epidemiological shift and contends with one of the highest diabetes prevalence rates worldwide. Comprehensive diabetes preventive methods should integrate hydration instruction with conventional focal points of food, exercise, and weight management. This study elucidates the intricate association between water intake patterns, lifestyle characteristics, and diabetes risk in Riyadh Province, Saudi Arabia, while expanding upon prior studies on hydration and metabolic health.

Participants who ingested less than the advised 2 liters of water daily exhibited markedly higher fasting blood glucose (102 mg/dL) and HbA1c levels (6.1%) in contrast to those adhering to appropriate intake recommendations, who sustained more optimal levels of 94 mg/dL and 5.6%, respectively. These findings correspond with the research conducted by Perrier et al. (2015), which shown that insufficient hydration disrupts glucose metabolism and increases glycemic indicators. Optimal hydration seems to improve insulin sensitivity, potentially alleviating the metabolic strain linked to diabetes and prediabetes, which is especially significant in Saudi Arabia's hot, arid climate.

Water quality appeared as a significant determinant; responders utilizing untreated water from wells or groundwater sources demonstrated a higher incidence of glycemic abnormalities. This discovery supports research indicating that pollutants in untreated water may interfere with metabolic functions, consequently elevating the risk of diabetes (Zhang et al., 2019). The identified rural-urban disparity—marked by reduced water consumption and restricted access to superior water sources among rural populations—highlights the essential influence of infrastructure on health outcomes. Urban inhabitants having access to treated municipal water had enhanced glycemic profiles, underscoring the imperative for equal access to clean water resources in all communities.

This study establishes that lifestyle factors such as obesity, inadequate diet, and lack of physical activity substantially increase diabetes risk among the Saudi population. The synergistic effect of obesity and inadequate hydration on metabolic health was notably significant, with a 40% prevalence of diabetes or prediabetes seen in obese adults (Hu et al., 2018). Moreover, diets rich in refined carbs, sugary drinks, and lipids were significantly linked to increased glycemic

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markers, supporting the findings of Imamura et al. (2015), which highlight the impact of food on diabetes risk.

Participants who engaged in at least 150 minutes of weekly moderate-to-vigorous physical activity demonstrated significantly enhanced glycemic profiles, indicating that exercise plays a moderating role in diabetes risk. This highlights the preventive advantages of consistent physical activity, which improves glucose utilization and may partially alleviate some consequences of inadequate hydration (Colberg et al., 2016).

Water consumption patterns, water quality, and lifestyle choices intersect to form a complex landscape of diabetes risk in Saudi Arabia. Hydration encompasses more than simple water consumption; it affects and is affected by qualitative and behavioral dimensions of nutrition and physical activity. The findings endorse recommendations for comprehensive treatments that encompass nutritional education, encouragement of physical activity, and enhanced access to clean water infrastructure to successfully mitigate the increasing diabetes burden in the varied communities of Saudi Arabia.

Conclusions

This study demonstrates that insufficient water consumption markedly elevates the incidence of diabetes in Riyadh Province, Saudi Arabia, irrespective of other recognized risk factors. Participants eating less than 2 liters daily had significantly elevated fasting blood glucose and HbA1c levels in comparison to those adhering to hydration guidelines. Moreover, water quality surfaced as an undervalued element, with users of untreated water exhibiting inferior glycemic profiles.

Rural-urban differences were significant, with rural inhabitants experiencing reduced water usage and restricted access to treated water sources. The protective benefit of sufficient hydration proved especially significant in the hot climate of Saudi Arabia and was amplified when coupled with physical exercise and appropriate nutrition.

The findings indicate that encouraging sufficient water consumption is a straightforward, economical strategy that has to be incorporated into holistic diabetes preventive efforts. In a nation with one of the highest diabetes prevalence rates globally, enhancing hydration behaviors may produce significant public health advantages. Future study should investigate the processes underlying these relationships and assess water-centric strategies in mitigating diabetes risk within this distinct demographic.

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Any residual errors or omissions are solely my responsibility.

Conflict of interest

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