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Adherence, Effectiveness and Utilization of Self-monitoring of Blood Glucose

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Abstract Aim: Diabetes mellitus (DM) is a common chronic disease which require frequent monitoring of blood sugar levels. The purpose of this study was to assess the handling and effectiveness of self-monitoring of blood glucose (SMBG) among the diabetic patients of Saudi Arabia. Methods: A questionnaire was designed and electronic survey was conducted through Google forms, a web-based application among adult male and female diabetes patients. A comprehensive information was collected regarding the utilization and effectiveness of the glucometer and its impact on health and life. A questionnaire divided into four sections containing questions related to personal information, SBGM device, measurement process and measurement outcomes was employed. Diabetologists were consulted to evaluate the responses of the participants. Results were evaluated using descriptive statistics on Microsoft Excel. Results: A total of 56 respondents (30 males and 26 females) participated in this survey study. The respondents were aged from 18 to 74 years. 80% of the respondents were diabetics. Out of 80%, 64% of respondents had type 1 diabetes while 36% had type 2 diabetes. The remaining 10% of respondents were non-diabetic and were using SMBG. Conclusion: It is highly asserted and emphasized to have only one glucometer. Additionally, healthcare professionals and DM patients should be well informed about the distortion and SMBG device limitations.

Keywords: *alcohol wipes, blood sugar, diabetes mellitus, self-blood glucose monitor*

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1. Introduction

According to World Health Organization, during 2017 approximately 7 million people were suffering with diabetes during 2017 in Saudi Arabia alone [1]. Among middle east countries, Saudi Arabia is ranked second highest and seventh in the world for the rate of diabetes [1]. Although, China is the country with the highest number of diabetic patients in the world with around (114 million patients), followed by India and USA [2]. However, these are the top most populated countries in the world. So the higher numbers of diabetics make sense but the surprising thing is that the percentage of the diabetic patients in USA, India and China is much lower than the percentage of diabetics in the Kingdom of Saudi Arabia. In USA, 10.79 % of the population have diabetes. Whereas, 10.33 % in India and 9.74 % in China. On the contrary, compared to 17.72 % of the population is diabetic in Saudi Arabia. So the rate of diabetes among the people of Saudi Arabia is higher as compared to USA, India and China. The worrying thing is the growing pattern of this chronic disease which has been noted in the Kingdom.

Diabetes Mellitus (DM) is a common chronic disease characterized by high blood sugar levels that occurs when insulin producing cells are damaged or destroyed and stop producing insulin [3]. An insulin is a hormone produced in the pancreas which adjust the amount of glucose in the blood [4]. The most common effect of uncontrolled diabetes is hyperglycemia which means high (hyper) glucose (gly) in the blood (emia). Hyperglycemia can cause serious health problems including nerve damage, cardiovascular complication, kidney problem, vision problem and issues with the feet and legs [5,6,7,8,9].

There are several types of DM, such as Type 1 diabetes, Type 2 diabetes, gestational diabetes, impaired glucose tolerance and impaired fasting glycemia. They differ from each other by insulin dependency or by the patient situation [10]. Both types. i.e., Type 1 diabetes and Type 2 diabetes are chronic as they persist for a long time and affect the way a body regulates blood sugar or glucose. In type 1 diabetes, the body does not make insulin [11]. Lack of insulin production is the main cause of this type of diabetes. In this case the body can still obtain glucose from the food but glucose does not release into the cells, where it is needed. So it stays in the blood and that makes the blood sugar level very high. Symptoms related to type 1 diabetes are Polyuria (excessive excretion of urine),

Polydipsia (thirst), constant hunger, fatigue, vision changes and weight loss. The symptoms of type 1 appear more quickly and is managed by taking insulin which controls the blood sugar. Type 2 diabetes is much more common than type 1. Type 2 diabetes is known as non-insulin dependent it results from body's inadequate use of insulin. Symptoms of type 2 diabetes are similar to type 1 diabetes but however are often less marked. This type of diabetes may be diagnosed years after the birth. This type 2 diabetes is related to adult patients but currently it has occurred increasingly in children [12,13].

Studies shows that physical inactivity, laziness and consumption of unhealthy foods (such as fatty and greasy food, sweet foods, and high flavored foods are common among the citizens of Saudi Arabia [14,15,16]. These foods and are causing obesity and DM [17,18]. Excess weight is one of the reasons of type 2 diabetes. Losing weight can help if the Body Mass Index is over. Exercise increases the insulin sensitivity of the cells, therefore, by performing physical activity on a regular basis type 2 diabetes can be prevented. Foods that are high in refined carbs and sugar increases blood sugar and insulin levels. Eating healthy foods with less fat and avoiding carbs, protein and fat can help reduce the risk. Some studies have found that by drinking water instead of other beverages may help control blood sugar and insulin levels, thereby reducing the risk of type 2 diabetes. Research shows that smoking contributes to many serious health conditions, including type 2 diabetes. Quitting smoking will benefit people with type 2 and have better control of their blood sugar.

Self-blood glucose monitor (SBGM) is a vital tool to gauge the level of glucose in the blood [19]. Also, SMBG has gained acceptance as a key component of diabetes care around the world. Knowing the importance of this tool, ministry of health Saudi Arabia has recently signed an agreement with a local medical devices manufacturer to distribute around 800,000 SBGMs. These devices are intended to be distributed free of charge to diabetic patients all around the kingdom to help them check their blood glucose level. However, previous studies indicate that there are several factors influencing SBGMs accuracy and precision such as device and strips handling techniques, storage environment, blood diseases, environmental factors (altitude, temperature and humidity) and design imperfection and limitation [20,21,22]. Therefore, the question arises if the SBGM is an effective tool among the diabetic patients of Saudi Arabia.

2. Methodology

A cross-sectional study was carried out between June and July 2019. Information was gathered by structuring a uniform questionnaire which was used to record the patients' answers to specially designed questions. Data was obtained through the use of google whose purpose was to ensure that each and every participant is able to clearly understand the questions and answer with an ease of mind. The questionnaire consisted of 35 questions and was divided into 4 sections. First section included personal information, health conditions and life style. The second section was about the device calibration, third was about the measurement duration and frequency of blood glucose checking and the final section was about the outcomes of blood glucose monitoring.

The patients of any type of DM were included in this study. The exclusion criteria were: (I) younger than 18 years of age; (II) unconscious or unable to learn how to use the blood glucose meter; (III) accompanied by other major diseases such as malignancies, end-stage liver disease, or kidney disease; and (IV) with an expected survival of less than 90 days. This study strictly followed the *Declaration of Helsinki* on medical protocol and ethics, and all patients signed the informed consents.

Senior diabetologists from King Fahad Medical City (KFMC) and King Abdul Aziz University Hospital (KAUH) were consulted while developing a standard short questionnaire for the assessment of participants. After their approval, questionnaires were sent randomly to relatives, friends, acquaintances and general users of google to get feedback. A satisfactory response was achieved and a total of 73 filled-in questionnaires were received from the participants. Results were evaluated using descriptive statistics on Microsoft Excel.

3. Results

A total of fifty-six completed forms were considered for analysis. Out of these fifty-six completed forms, thirty were of male respondents while twenty-six were of female. The respondents were aging from 18 to 74 years. The majority of respondents (64%) had Type 2 diabetes. Although, most of the respondents belonged to middle region of Saudi Arabia, there were few who belonged to East, West, South and North regions as well. Regarding the knowledge about physical activity, respondents were well aware of the fact that physical activity helps to improve insulin sensitivity and insulin would better able to help the muscle and fat cells to use the glucose in the blood when exercise is regularly done. However, forty-three respondents said they don't exercise because they do not have time, neither they perform any physical activity like brisk walking etc. It was found that forty-seven participants were non-smokers. Forty-two participants did not show any commitment about a proper diabetic diet or any food plan.

Almost three quarters of respondents gave their feedback that they hold and use their devices for more than one year while 39% had been monitoring their blood glucose with the same device for the past three years. Only 5% of the respondents were found to have been using their devices for the last six months, representing the lowest percentage of the total sample 9%. In context of keeping the device and the strips within ventilated area, 32 participants keep their devices ventilated; 34 of the participants keep their strips also in ventilated area. However, 18 participants did not check strip's expiration date. Also 37 participants were unfamiliar with the "calibration" of the device. Thirty-one participants own more than one device representing 55%. In addition, 20 participants were not using the latest device. Participants who were using their device once or twice a day represented the largest segment of the sample.

Participants using alcohol wipes were 32. On the contrary, 15 participants did not care to clean their hands

before using the device. In case of hypoglycemia, 9 of the participants opted to decrease the insulin dose or pill. However, 52 participants opted to have a meal to increase their blood sugar level. Whereas, in case of hyperglycemia, most of the participants opted to increase the dose of medication. Finally, participants were asked if the device presents an unpredictable reading according to their feeling what action they will take. The results in graphical form are presented in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6.

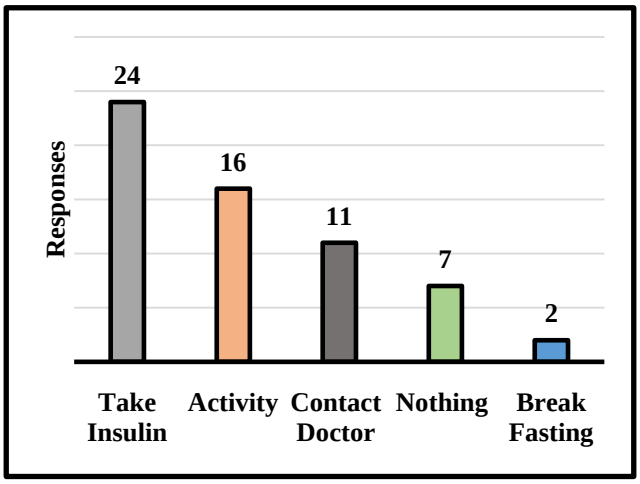

Figure 1. In case of hyperglycemia (130-250) mg/dL while fasting

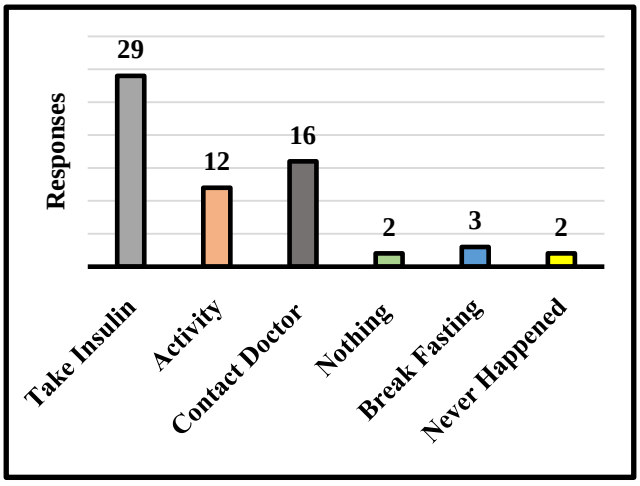

Figure 2. In case of hyperglycemia more than 250 g/dL while fasting

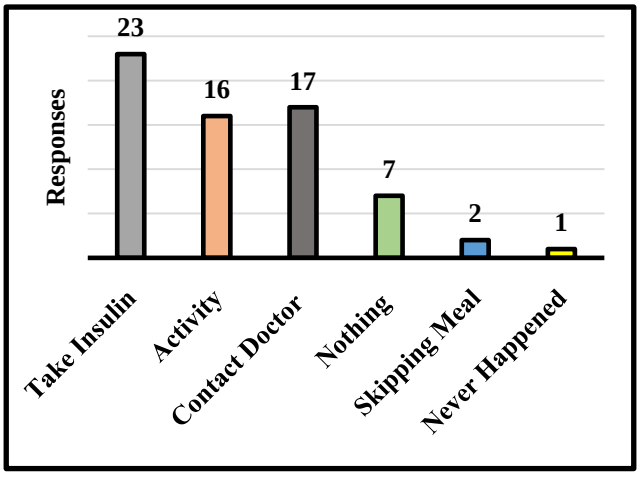

Figure 3. In case of hyperglycemia (180-250) mg/dL

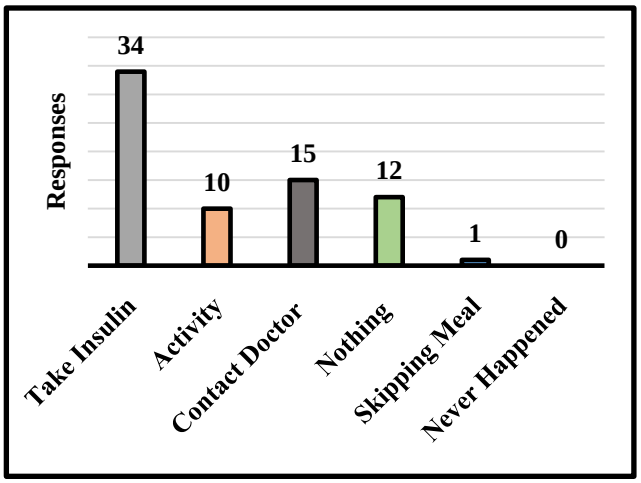

Figure 4. In case of hyperglycemia (250-320) mg/dL

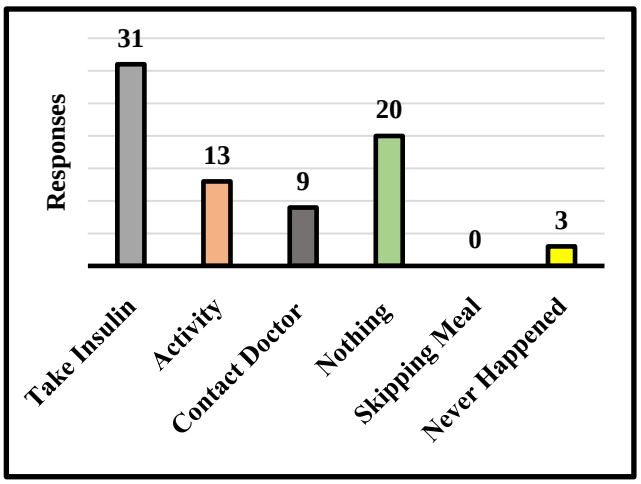

Figure 5. In case of hyperglycemia more than 320 mg/dL

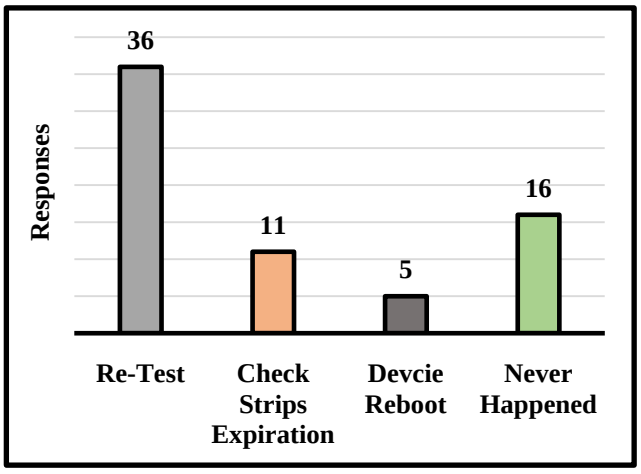

Figure 6. Participants satisfaction with the SBGM results

4. Discussion

Altitude, temperature and relative humidity have a considerable effect on the performance of SBGM. Most of the SBGMs depend on oxygen to determine the concentration of glucose in the blood. Quite a people live at high altitudes across the Kingdom and pressure of the oxygen is lower at heights. An altitude of 5000 to 10000 feet above sea level is considered to be high and Taif city

in Mecca Province is at an elevation of 6165 feet. The amount of oxygen in the air decreases at altitude and can negatively affect the results of the SBGM. The glucometer studied, there is about 1-2% underestimation of blood glucose for every 1000 feet of elevation [23]. The lower the partial pressure of oxygen, the lower the blood glucose value. There is a strong chance that diabetic patients living at high altitudes are taking lower insulin doses than the required dose because of the self-monitoring of wrong blood glucose reading and these meters can be affected by the decreased oxygen needed for the enzymatic reaction to occur. Further studies are needed to check the accuracy of glucometer at different altitudes in order to better understand the relationship between the performance of glucometer and high altitudes.

The accuracy and reliability of SBGM device is of great significance. Glucose meter is acceptable as long as it is giving accurate readings but these meters can become less accurate over time. Experience shows that a typical glucose meter lasts for one to two years [24]. It is therefore, recommended that the device should be replaced after one year of usage. It is very important to calibrate the blood sugar meters to ensure the accuracy of the test equipment [25]. Users should read the operation manual thoroughly before using the instrument and follow calibration instructions. Small devices that measure and display blood sugar level are usually accurate and give correct readings but sometimes they may be incorrect. In order to ensure that the blood glucose readings obtained from the meter are accurate, it is necessary to compare the readings obtained with those done at the laboratory. Our findings show that 55% of the participants had two or more SBGM devices, and 64% of them use the old devices. It might be possible that two SBGM devices give misleading readings. Significantly important, user can't discriminate which reading is accurate. Thus, error probability is even higher with two devices. Contaminations and alcohol wipes critically disturb SBGM readings [26]. Our results show that 86% of participants either using alcohol wipes or don't wash their hands before evaluating the blood glucose. It's known that in Islamic society, diabetic patients manage their condition in Ramadan (fasting month) in a special way. It is also known that the normal ranges of glucose level vary in case of fasting. That is to say, in case of hyperglycemia while fasting, 42.5% of the participants tend to use medications (e.g. insulin or pills). On the other hand, in case of normal and extreme hyperglycemia levels in non-fasting days, an average of 41% of the participants also tend to use medications. Medications are the most crucial decision made by participants in the study. The study did not have adequate people from different races and ages to get information if SMBG may help manage blood sugar in particular groups of people. The study included people only of the Saudi origin only. The results may vary for people from other cities.

In conclusion, we encourage the users to have only one glucometer to avoid errors. Also, it will be more accurate and quality emphasizing if the companies tool up their products with an indicator that tells the user the date it operated, in case the user has more than one device.

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