Original Article

Pseudohyperglycemia: Effects of Unwashed Hand after Fruit Peeling or Handling on Fingertips Blood Glucose Monitoring Results

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Abstract

Background: Self-monitoring of blood glucose (SMBG) is an important component of management for diabetes mellitus (DM), especially in T1DM and T2DM patients who are on insulin therapy. Adequate blood glucose monitoring and prompt intervention are necessary to prevent blood glucose (BG) fluctuation and delay long-term diabetes complications. People with DM are advised to clean their hands before SMBG to remove any dirt or food residue that might affect the reading. **Aim:** The study tested the hypothesis that falsely elevated BG levels from fingertip occur after peeling or handling fruits in an unwashed hand. **Methods:** Fifty apparently healthy nondiabetes volunteers were enrolled. Capillary BG samples were collected from the fingertips after peeling or handling apple, orange, banana, watermelon, and pawpaw, followed by no hand washing for 1 h, cleaning the fingertip with alcohol swab once, five times, and washing hand thoroughly with tap water and drying. These samples were then analyzed with two different glucose meters. **Results:** The mean BG values, measured from fingertip blood samples after peeling, and handling any of the fruits followed by no hand washing were significantly high, even after cleaning fingertip with a swab of alcohol once. However, there were no significant difference in BG levels measured after peeling and handling fruits followed by hand washing and the level of BG before peeling and handling fruits. **Conclusion:** Handling of peeled fruits with no hand washing with tap water is associated with overestimation of capillary BG (Pseudohyperglycemia) monitored with glucose meters.

Keywords: Diabetes, Fruits, Glucose meter, Hand washing, Pseudohyperglycemia, Self-monitoring of blood glucose

Introduction

Glucose meters are widely used today both in the inpatient and outpatient settings and by patients at home to monitor therapy. Self-monitoring of blood glucose (SMBG) is an integral component of diabetes care and if used optimally, essential for monitoring glycemic control. The use of glucose meters helps to provide real-time documentation of fluctuations in blood glucose (BG), allowing adjustment of treatment strategies as well as recognizing out of range glucose values.[1,2] The American Diabetes Association recommends SMBG for diabetes management as a key component of the disease management.[3] This practice is particularly important in individuals with type 1 diabetes who are usually on multiple dose of insulin and those with type 2 diabetes who are also on

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multiple doses of insulin injections. In addition, it is important in individuals who are prone to recurrent hypoglycemia and those with hypoglycemic unawareness. Studies in a variety of inpatient settings report better clinical outcomes associated with improved glycemic control,[4-7] occasioned by regular BG monitoring. Glucose meters are utilized by a diverse population of patients, representing all ages, and severity of medical conditions. Both patients and health-care practitioners (HCPs) need a certain level of confidence in the results of glucose meters. Having access to devices which allow people with diabetes to perform SMBG is an essential tool in their self-management. Probably, many people with diabetes and clinicians who rely on these meters are sometimes unaware of limitations and other factors that may affect the accuracy of glucose meter results. There are numerous circumstances where misleading or unreliable results may be obtained, which in turn can affect clinical decision-making resulting in the potential for patients' harm.[8] Quite clearly, the ability of an individual (patient with diabetes and HCP) to interpret and in extension manage any given situation correctly fundamentally depends on the accuracy of the results.

Many factors affect the accuracies of glucose meter; these are broadly divided into analytical variables (which are intrinsic to glucose meter and glucose strips), and preanalytical/operator-dependent variables (related to patients). Operator-dependent inaccuracy is the most significant source of blood sugar errors, especially in outpatient setting.[9,10] These common operator-related factors include dirty fingers at the site of BG testing, which is not cleaned properly. Blood samples for SMBG are commonly and easily obtained from finger prick after the skin has been cleaned with an alcohol swab. However, falsely elevated or reduced BG may be obtained from the blood obtained from the fingertip. Overestimation of BG levels may be obtained in fingertip after peeling fruits, especially if the juice stained the fingers that were not properly cleaned. This is due to the constituents of these fruits which include fructose, glucose, and trace metals, whose contamination of finger site affect BG levels causing falsely elevated values. Hence, the study aims to test the hypothesis that falsely elevated BG levels from fingertip occur after peeling fruits or handling fruits in an unwashed hand.

Methods

Study location

This study was carried out at the Diabetes clinic of LAUTECH Teaching Hospital, Ogbomoso, Southwest Nigeria. It is a tertiary health institution that caters for more than 1.5 million people. The hospital receives patients from villages, towns within Oyo State, and neighboring states.

Participants

The study recruited fifty healthy volunteers who were members of hospital staff (doctors, nurses, and ward orderlies) and physiology students. Using $\alpha = 0.5$ and $\beta = 0.20$, the sample per group was estimated to be about nine individuals.[11] The participants were selected randomly using a closed ballot box. They were all confirmed to be free of diabetes with normal fasting BG (FBG) on three different days. Their age ranged from 19 to 37 years.

Blood glucose determinations

Capillary BG samples were collected in the fasting state from the fingertip of healthy volunteers in the fasting state (07:30 a.m. – 09:30 a.m.) following finger prick with a sterile lancet. BG levels were measured using two different glucose meters (Accu-Chek – Roche Diagnostics Corporation, Indianapolis, IN, USA, and Fine test – Codix Pharma Limited, Ilupeju, Lagos).

Procedure

Capillary blood samples for BG estimation were collected in the fasting state from the fingertip of volunteers before handling or peeling different types of fruits which included orange (*Citrus sinensis*), watermelon (*Citrullus lanatus*), apple (*Malus domestica*), banana (*Musa acuminata*), and pawpaw (*Carica papaya*). Thereafter, capillary BG levels were measured 1 h after they had peeled one of the kinds of fruits, with no hand washing or cleaning with alcohol swab. Then, BG levels were done after cleaning the fingertip with alcohol swab once using the first drop of blood; using the second drop; after cleaning fingertip with alcohol swab five times and drying hands. Finally, capillary BG levels were measured after the hands were thoroughly washed with tap water and dried. These procedures were done for each set of fruits in turn with ten participants handling each fruit. The samples were analyzed immediately with the two different portable glucose meters. Blood samples were obtained from the fingertips of the hand that handled the fruit and its skin. In this study, peeling the fruit involved holding the fruit in one hand and using the fingers of the other hand or a kitchen knife. The participants did not eat the fruits handled during the experiment. Participants were also allowed to hold the skinless fruits after peeling. Ethical approval was obtained from the Ethical Review Committee of LAUTECH Teaching Hospital, Ogbomoso. Informed consent was obtained from the participants after explanation of the purpose of the study and the procedure.

Statistical analysis

The Statistical Package for Social Sciences software (SPSS Inc., version 17, Chicago, IL, USA) was used for data analysis. Quantitative data were expressed as mean ± standard deviation and median (range). Comparisons were made by Student's *t*-test (two-tailed for dependent samples). Participants' characteristics were compared by one-way analysis of variance for continuous variables. *P* – value was considered statistically significant at <0.05.

Results

The study consisted of fifty participants (22 males and 28 females) with a mean age of 25.06 (4.34) years. The other demographic characteristics and FBG levels of the participants as determined by the two glucose meters are shown in Table 1.

The initial FBG of the participants peeling/handling the five fruits (Pawpaw, Watermelon, Banana, Orange, and Apple) was 80.2 (3.43), 91.8 (8.08), 81.0 (7.93), 82.9 (8.39), and 77.2 (7.10) mg/dl, respectively. The BG levels estimated by glucose meters using fingertip blood samples obtained after peeling or handling skinless fruits from healthy participants without diabetes not followed by hand washing nor cleaned with alcohol swab were markedly elevated compared to the BG levels before handling or peeling fruits. BG level was highest after peeling and handling pawpaw (354.9 [221.98] mg/dl), followed by apple (273.5 [138.24] mg/dl), and lowest value obtained after handling banana fruit (111.4 [34.96] mg/dl). The differences in the mean BG levels immediately after handling peeled fruits compared to before peeling or handling fruits were significantly higher for all the fruits except for banana fruit. In particular, BG levels in some participants after handling peeled pawpaw and apple were extremely high-recorded as "HI" in both glucose meters (BG levels >600 mg/dl, which is the upper limit that can be measured by most glucose meters). The same observation was noticed even from samples obtained 1 h after peeling or handling fruits followed by unwashed hands with water, nor cleaned with alcohol swab. However, there was no significant difference in BG levels measured after peeling and handling skinless fruits, followed by washing hands thoroughly with tap water, and BG levels measured before peeling and handling fruits [Table 2]. In comparison with initial BG levels, there were differences in the BG levels between when fingertip was cleaned once and when it was cleaned five times with alcohol swab in all the fruits except for pawpaw. However, BG levels measured after cleaning fingertip with alcohol swab five times was significantly higher compared to BG level from fingertip of hand washed with tap water in those who had previously peeled or handled pawpaw (151.7 [150.49]; $P = 0.05$ vs. 80.3 [8.12]; $P = 0.86$]. There was no such difference in other fruits. The patterns of BG changes are as shown for the two glucose meters used in Figures 1 and 2.

The same procedures were done using a different glucose meter with the similar result obtained [Table 3].

Table 1: Sociodemographic characteristics of the participants

Demographic	Male (mean [SD]) *n*=22 (44%)	Female (mean [SD]) *n*=28 (56%)
Age (years)	25.06 (4.34)	
Mean (SD)	25.77 (4.74)	24.50 (3.40)
Range	19-37	20-36
FBG - fine test (mg/dl)	89.56 (18.20)	
Mean (SD)	90.82 (12.92)	88.57 (21.66)
Range	56-113	40-148
FBG - Accu-Chek (mg/dl)	82.62 (8.53)	
Mean (SD)	84.91 (9.99)	80.82 (6.85)
Range	71-110	70-94

SD: Standard deviation, FBG: Fasting blood glucose

Discussion

SMBG using glucose meter provides the ability for diabetes patients to test their own BG so as to adjust insulin dosage to control their glucose needs. Reliability of results can be affected by many factors including environmental; operators may inadvertently influence meter results.

Hand washing is important to remove substances from the skin that could falsely elevate glucose readings.[12]

Table 2: Comparison of the different blood glucose levels with the initial blood glucose for the participants

Fruits	Initial BG	BG after fruit	BG after 1 h	BG after 1 h (2)	BG single swab	BG five swabs	BG (hand washing)
Pawpaw							
Mean (SD)	80.2 (3.43)	354.9 (221.98)	342.0 (184.49)	318.3 (198.22)	157.4 (61.81)	151.7 (150.49)	80.3 (8.12)
P		<0.01	<0.01	<0.01	0.01	0.05	0.86
Water melon							
Mean (SD)	91.8 (8.08)	219.6 (155.55)	168.9 (62.84)	156.4 (60.96)	131.1 (56.69)	100.4 (10.37)	85.67 (7.23)
P		0.05	0.02	0.02	0.01	0.30	0.79
Banana							
Mean (SD)	81.0 (7.93)	111.4 (34.96)	105.6 (12.70)	109.4 (30.32)	94.2 (20.36)	82.5 (10.07)	78.2 (7.21)
P		0.06	0.15	0.05	0.08	0.54	0.67
Orange							
Mean (SD)	82.9 (8.39)	129.1 (44.28)	130.4 (53.79)	121.4 (35.16)	102.5 (20.06)	84.4 (12.18)	83.8 (8.30)
P		0.02	0.03	0.06	0.10	0.37	0.58
Apple							
Mean (SD)	77.2 (7.10)	273.5 (138.24)	268.4 (177.31)	215.4 (118.12)	156.9 (116.29)	128.6 (109.31)	87.1 (9.95)
P		<0.01	<0.01	0.01	0.04	0.06	0.35

BG: Blood glucose, SD: Standard deviation

Table 3: Comparison of two glucometers

	Pawpaw	Watermelon	Banana	Orange	Apple	*P*
FBS						
Fine test	79 (46-95)	99 (77-148)	92.5 (83-108)	88.5 (83-95)	85.5 (40-146)	0.03
Accu-Chek	81 (75-85)	90 (82-110)	80 (71-94)	81.5 (73-98)	74.5 (70-94)	0.01
Blood sugar after touching fruit						
Fine test	472 (236-600)	320.5 (167-600)	125 (95-180)	161 (83-403)	418 (119-600)	<0.001
Accu-Chek	397 (150-600)	143.5 (118-600)	101.5 (83-201)	122 (79-232)	313.5 (77-426)	0.01
Blood sugar 1 h after (first drop)						
Fine test	300.5 (140-600)	234.5 (103-376)	130.5 (108-171)	155.5 (88-470)	237.5 (96-529)	0.02
Accu-Chek	265 (145-600)	164 (99-278)	105.5 (86-126)	114.5 (78-253)	209.5 (101-600)	<0.001
Blood sugar 1 h after (second drop)						
Fine test	360 (135-600)	299 (123-600)	156.5 (86-371)	121 (83-600)	362.5 (98-600)	0.01
Accu-Chek	253.5 (124-600)	362 (138-600)	99.5 (85-186)	117 (88-192)	195 (94-424)	0.02
Blood sugar after single alcohol swab						
Fine test	135.5 (90-600)	108 (95-600)	101 (79-158)	87 (81-194)	225.5 (93-600)	0.01
Accu-Chek	103 (88-600)	104 (87-240)	88 (77-141)	105.5 (74-135)	103.5 (89-435)	0.10
Blood sugar after five alcohol swab						
Fine test	88.5 (81-600)	106 (74-122)	84 (76-92)	86.5 (51-99)	108 (54-600)	0.20
Accu-Chek	88.5 (81-600)	97 (88-121)	80 (68-101)	87 (62-102)	90 (83-438)	0.33
Blood sugar after hand washing						
Fine test	88.5 (77-191)	86.5 (74-140)	85.5 (74-135)	85 (76-99)	93 (80-115)	0.59
Accu-Chek	82 (68-91)	88 (70-94)	79.5 (64-89)	84.5 (68-98)	85.5 (77-107)	0.11

600 mg/dl was recorded for blood glucose recorded as "HI" in the glucometers

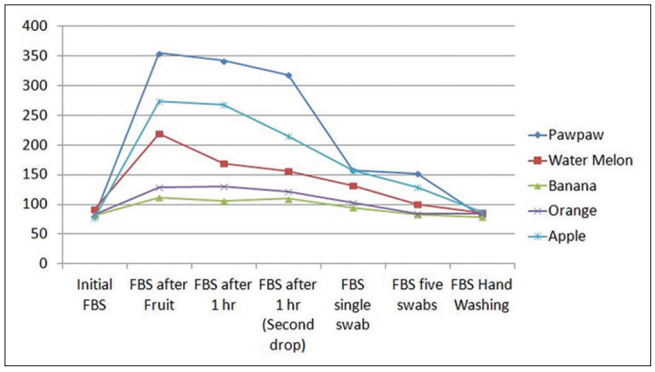

Figure 1: BG level using the Accu-Chek glucometer

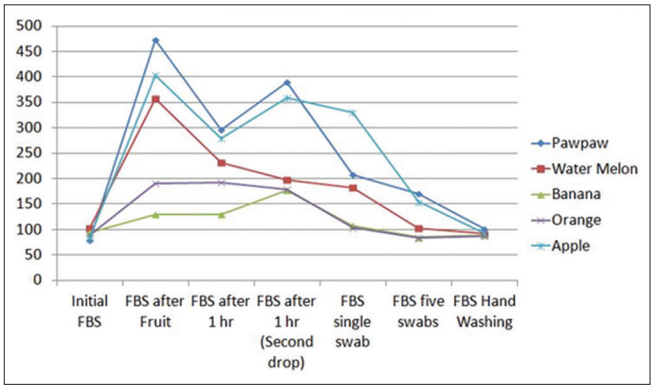

Figure 2: BG level using the Fine test glucometer

The findings of this study demonstrated falsely elevated BG after handling of fruits, with no hand washing or cleaning with alcohol swab. This finding is consistent with the previous finding by Hirose *et al.*,[12] who made his study in Japan on healthy persons without diabetes using three types of fruits. This finding may be due to traces of fruits which contain glucose and fructose among other constituents left on the fingers. A similar finding was made by Genevra,[13] who noted that invisible bits of fruits left on patients' fingers and hands when they do finger prick test can make their BG level falsely high.

The differences in the BG levels after handling different fruits might be related to the glycemic index (GIs) of the fruits. The GIs of these tropical fresh fruits varied from 86% for pawpaw to 72% for watermelon, 62% for banana, 40% for orange, and 39% for apple.[14,15] Hence, these results indicate the need to wash hand thoroughly with tap water and drying them after peeling or handling fruits. This should be recommended to patients and HCPs to ensure accurate monitoring of BG levels when using blood samples obtained by pricking the fingertip.

Conclusion

In this study, we demonstrated the need to wash hands including fingers with tap water thoroughly after fruit peeling or handling for accurate BG monitoring using capillary blood from the fingertip. Falsely elevated BG levels (Pseudohyperglycemia) were obtained when subjects did not wash their hands with water after fruit peeling or handling. These misleading or unreliable BG readings may adversely affect clinical decision resulting in potential harm to individuals with diabetes. However, these false BG reading did not occur when fingertip

was cleaned with alcohol swab, especially when cleaned up to five times.

Hence, the need for patients' education regarding their glucometers can prevent false readings and inadvertent admission of excess insulin resulting in severe hypoglycemia.

This study is limited by the fact that it used only healthy nondiabetic participants. However, by extrapolation, similar results would be expected among diabetics since this only tested impact of touching or handling fruits on blood sugar checked with glucometer.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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