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Original Research Article

Effect of Glucose on Accommodation Lag of Young Adults

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ABSTRACT

Glucose is the primary source of energy for the body's metabolism. Accommodation lag refers to the slightly less accommodation level to a target by an individual. This study was carried out to determine the effect of glucose on the accommodation lag of young adults. This study was a clinical and case control study carried out at the Department of Optometry Teaching Clinic, Federal University of Technology, Owerri, Imo state, Nigeria. An informed consent was gotten from all the subjects who were part of the study. Case history, visual acuity, external eye examination, ophthalmoscopy, static retinoscopy and glucometry were clinical tests performed on the subjects. The baseline accommodation lag of the subjects was first measured by taking the difference of the static and dynamic retinoscopic finding. Then, 12.5g and 19g of glucose powder was administered orally to the female and male subjects respectively in consideration of body weight. The accommodation lag values of the subjects were measured again after 30, 60 and 90 minutes of glucose administration. Results showed that for the female subjects, the mean accommodation lag before glucose intake was 0.58±0.38 D. It became 0.91±0.40 D, 0.81±0.51 D and 0.69±0.48 D after 30, 60 and 90 minutes of glucose intake respectively. For the male subjects, the mean accommodation lag before glucose intake was 0.61±0.08 D. It became 0.73±0.15 D, 0.73±0.25 D and 0.63±0.11 D after 30, 60 and 90 minutes of glucose intake respectively. SPSS data analysis using the one-way ANOVA at 0.05 level of significance showed that there was a significant difference ($P < 0.05$) in accommodation lag before and after 30, 60 and 90 minutes of glucose intake. Eye care practitioners were advised to monitor the blood glucose values of their patients especially when there are sudden changes in their accommodative functions.

Keywords: Glucose, Accommodation, Accommodation lag, Retinoscopy, Amplitude of Accommodation

INTRODUCTION

Glucose is the primary source of energy for the body's metabolism and is being used up by the body via the insulin activities which breaks it down into glycogens stored up in cells. [1] Glucose is one of the most abundant organic compounds in nature. All major dietary carbohydrates contain glucose, either as their building blocks, as in starch and glycogen, or together with another monosaccharide, as in sucrose and lactose. It is also a major constituent of many Oligosaccharides notably sucrose and of many glycosides. [2] The body which comprises of muscles, the brain, liver, heart etc., requires a lot of energy to work and this energy is gotten from the food we eat. Naturally, glucose can be found in ripe fruits, nectar of flowers, leaves, sap, blood, milk of mammals and as glycogen in the liver and muscles. [3] In a refined state, it is found in baked food beverages, sweeteners, juice (canned), oral drugs (glucose supplement), intravenous fluids and antibodies. Some cells in the human body including the red blood cells and cells in the brain, central nervous system (CNS) and muscles rely on glucose for energy. [3] After food consumption, the blood sugar begins to rise within 15 to 30minutes if there is a carbohydrate content. The blood glucose level in a typical person after an overnight fast is between 80-100mg/ml. After meals, a normal evaluation between 120 – 130mg/ml is expected. [4] The body digests the food we eat by mixing it with fluids in the stomach such as acids and enzymes. When the food is being digested by the stomach, the carbohydrates (sugar and starch) in the food breaks down into another type of sugar called glucose. The stomach and small intestine absorb the glucose and then releases it into the blood stream and it is either used immediately for energy or stored in our bodies for later use. However, the body needs insulin for use or storage of glucose for energy. Without this insulin, the glucose stays in the blood stream, keeping blood sugar level high. [5] Glucose is transported from the intestine or liver to body cells via the blood stream and is made available for cell absorption via the hormone insulin, which is produced by the body primarily in the pancreas. When this insulin is released from the pancreas, it travels through the blood stream to the body's cells and tells the cell doors to open up to let the glucose in. Once inside, the cells convert glucose into energy to be used immediately or to be stored for later use. Blood sugar level drops as glucose moves from the bloodstream into cells and the fluctuation in insulin and blood sugar occur many times during the day and night. [3] The amount of glucose and insulin in the blood stream depends on when we eat and how much. Under normal working condition, the body can keep blood sugar at a normal level which is between 70-120mg/dl. Even in non – diabetics, blood sugar level can go up as high as 180mg/dl during or just after a meal. Then within two hours after meal it should drop to like 140mg/dl and as low as 70mg/dl after several hours without food consumption. [5]

For the purpose of vision, glucose is very vital for the efficient functioning of visual cells. It is necessary for efficiency in visual functions such as sustaining the pump mechanism of the cornea, especially the endothelial layer. It is also required in the generation of retinal electrical activity and production of glutathione for optimal muscarinic action of the ciliary body especially during accommodation and papillary fluctuation for lens metabolism. [6] Despite periods of feeding and fasting in normal individuals, plasma glucose remains in a narrow range between 4 and 7mm regulating the balance between the release of glucose into circulation by either absorption from the intestine or the breakdown of stored glycogen in the liver and the uptake and metabolism of blood glucose by peripheral tissues. These processes are regulated by a set of metabolic hormones. [7] Glucose enters the lens by simple diffusion and facilitated diffusion and it is rapidly metabolized via glycolysis such that the level of free glucose in the lens is greater than 1/10 glucose in aqueous. Dextrose monohydrate is the monohydrate form of D-glucose, a natural monosaccharide and carbohydrate. It is a simple sugar made from corn. It serves to replenish lost nutrients and electrolytes, providing metabolic energy. It is the primary ingredient in oral rehydration salt (ORS) and is used in intravenous (IV) fluids to provide nutrients to patients under intensive care who are unable to receive through the oral route. [7] Solutions containing dextrose restore blood glucose levels, provide calories, may aid in minimizing liver glycogen. It also plays a role in protein production and lipid metabolism. The body uses it quickly for energy because it is a simple sugar. [8]

Accommodation is defined as the process by which the crystalline lens varies its focal length in response to changes in the vergence of incident light. [9] It is simply the ability of the human eye to change its focus from far to near and from near to far. [10] Accommodation lag refers to the slightly less accommodation level to a target by an individual. [11] This lag of accommodation represents the amount of plus lens power that must be added to a patients' distance correction if he fails to accommodate at near. Accommodation lag can be measured by means of near point tests such as dynamic retinoscopy and binocular crossed-cylinder tests. These tests, in young adults, provides the clinician with the patient's "accommodation lag" which is always between zero and + 1.00Ds, with an average of + 0.50D. Whereas for presbyopes, the test provides the clinician with the tentative addition needed by the patient. [9] This study was carried out to determine the effect of glucose on the accommodation lag of young adults.

MATERIALS AND METHODS

This study was a clinical and case control study carried out at the Department of Optometry Teaching Clinic, Federal University of Technology, Owerri, Imo state, Nigeria. An informed consent was gotten from all the subjects who were part of the study. Case history, visual acuity, external eye examination, ophthalmoscopy, static retinoscopy and glucometry were clinical tests performed on the subjects. The baseline accommodation lag of the subjects was first measured by taking the difference of the static and dynamic retinoscopic finding. Then, 12.5g and 19g of glucose powder was administered orally to the female and male subjects respectively in consideration of body weight. The accommodation lag values of the subjects were measured again after 30, 60 and 90 minutes of glucose administration. Data was collected and uploaded into the Statistical Package for Social Sciences (SPSS) version 21 and the one-way ANOVA was used to test the null hypotheses at 0.05% level of significance and 95% confidence interval.

RESULTS

A total of 30 subjects comprising 14males and 16 females were used for this study. All the subjects were between 18 and 30 years. The accommodation lag was measured on both eyes separately. So for the female subjects, 32 eyes were measured and for male subjects, 28 eyes were measured. Table 1 showed the accommodation lag before 12.5g of glucose intake among female subjects. The table showed that 18 (56.25%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 12 (37.50%); for 1.01-1.50, 2 (6.25%). Table 2 showed the accommodation lag 30 minutes after 12.5g of glucose intake among female subjects. The table showed that 10 (31.25%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 12 (31.50%); for 1.01-1.50, 10 (31.25%). Table 3 showed the accommodation lag 60 minutes after 12.5g of glucose intake among female subjects. The table showed that 15 (46.88%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 7 (21.88%); for 1.01-1.50, 7 (21.88%); for 1.51 – 2.00, 3 (9.36%). Table 4 showed the accommodation lag 90 minutes after 12.5g of glucose intake among female subjects. The table showed that 14 (43.75%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 12 (37.50%); for 1.01-1.50, 6 (18.75%).Table 5 showed the descriptive statistics on accommodation lag of female subjects. The table showed that before administration of 12.5g glucose, the mean value was 0.58 with a minimum and maximum value of0.00 and 1.25 respectively. After 30 minutes, the mean value was 0.91 with a minimum and maximum value of 0.25 and 1.50 respectively. After 60 minutes, the mean value was 0.81 with a minimum and maximum value of0.00 and 1.50 respectively. After 90 minutes, the mean value was 0.69 with a minimum and maximum value of 0.00 and 1.50 respectively.

Table 6 showed the accommodation lag before 19g of glucose intake among male subjects. The table showed that 16 (57.14%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 12 (42.86%). Table 7 showed the accommodation lag 30 minutes after 19g of glucose intake among male subjects. The table showed that 12 (42.86%) subjects' eyes had an accommodation lag of 0.00-0.50 D and 0.51-1.00; for 1.01-1.50, 4 (14.28%). Table 8 showed the accommodation lag 60 minutes after 19g of glucose intake among male subjects. The table showed that 9 (32.14%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51 – 1.00, 15 (53.58%); for 1.01-1.50 and 1.51 – 2.00, 2 (7.40%). Table 9 showed the accommodation lag 90 minutes after 19g of glucose intake among male subjects. The table showed that 18 (64.29%) subjects eyes had an accommodation lag of 0.00-0.50 D; for 0.51-1.00, 7 (25.00%); for 1.01-1.50, 3 (10.71%). Table 10 showed the descriptive statistics on accommodation lag of male subjects. The table showed that before administration of 19g glucose, the mean value was 0.61 with a minimum and maximum value of 0.00 and 1.00 respectively. After 30 minutes, the mean value was 0.73 with a minimum and maximum value of 0.25 and 1.50 respectively. After 60 minutes, the mean value remained at 0.73 with a minimum and maximum value of 0.00 and 1.75 respectively. After 90 minutes, the mean value was 0.63 with a minimum and maximum value of 0.25 and 1.50 respectively. SPSS data analysis using the one-way ANOVA at 0.05 level of significance showed that there was a significant difference [P(0.011) < 0.05] in accommodation lag before and after 30, 60 and 90 minutes of glucose intake.

Table 1: Accommodation lag before 12.5g of glucose intake among female subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	18	56.25
0.51 – 1.00	12	37.50
1.01 – 1.50	2	6.25
1.51 – 2.00	0	0.00
Total	32	100.00

Table 2: Accommodation lag 30 minutes after 12.5g of glucose intake among female subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	10	31.25
0.51 – 1.00	12	31.50
1.01 – 1.50	10	31.25
1.51 – 2.00	0	0.00
Total	32	100.00

Table 3: Accommodation lag 60 minutes after 12.5g of glucose intake among female subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	15	46.88
0.51 – 1.00	7	21.88
1.01 – 1.50	7	21.88
1.51 – 2.00	3	9.36
Total	32	100.00

Table 4: Accommodation lag 90 minutes after 12.5g of glucose intake among female subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	14	43.75
0.51 – 1.00	12	37.50
1.01 – 1.50	6	18.75
1.51 – 2.00	0	0.00
Total	32	100.00

Table 5: Descriptive statistics on Accommodation lag of female subjects

Time of Measurement	Min	Max	Mean	S.D
Before Glucose Intake	0.00	1.25	0.58	0.38
After 30 minutes	0.25	1.50	0.91	0.40
After 60 minutes	0.25	1.75	0.81	0.51
After 90 minutes	0.00	1.50	0.69	0.48

Min = Minimum, Max = Maximum. S.D. = Standard Deviation

Table 6: Accommodation lag before 19g of glucose intake among male subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	16	57.14
0.51 – 1.00	12	42.86
1.01 – 1.50	0	0.00
1.51 – 2.00	0	0.00
Total	28	100.00

Table 7: Accommodation lag 30 minutes after 19g of glucose intake among male subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	12	42.86
0.51 – 1.00	12	42.86
1.01 – 1.50	4	14.28
1.51 – 2.00	0	0.00
Total	28	100.00

Table 8: Accommodation lag 60 minutes after 19g of glucose intake among male subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	9	32.14
0.51 – 1.00	15	53.58
1.01 – 1.50	2	7.40
1.51 – 2.00	2	7.40
Total	28	100.00

Table 9: Accommodation lag 90 minutes after 19g of glucose intake among male subjects

Accommodation Lag (D)	n	%
0.00 – 0.50	18	64.29
0.51 – 1.00	7	25.00
1.01 – 1.50	3	10.71
1.51 – 2.00	0	0.00
Total	28	100.00

Table 10: Descriptive statistics on Accommodation lag of male subjects

Time of Measurement	Min	Max	Mean	S.D
Before Glucose Intake	0.00	1.00	0.61	0.08
After 30 minutes	0.25	1.50	0.73	0.15
After 60 minutes	0.00	1.75	0.73	0.25
After 90 minutes	0.25	1.50	0.63	0.11

Min = Minimum, Max = Maximum. S.D. = Standard Deviation

DISCUSSION

Our effort to change focus from far to near and from near to far is due to accommodative ability. On the other hand, lag of accommodation is the slightly less accommodation level to a target of an individual than is expected. [11] Accommodation lag represents the extra plus lens power that must be added to a patient's distance correction if he fails to accommodate at near and it's usually between zero and +1.00D with an average of +0.50D. For the purpose of this research, the females were given 12.5g of glucose and the males 19g of glucose. This was given while taking into consideration the maximum daily intake of sugar which is 37.5g and 25g for men and women respectively. [12] From the results obtained above, the male subjects had a mean accommodation lag of 0.73±0.39D after 30 minutes of 19g of glucose intake, 0.73±0.50D after 60 minutes and 0.63±0.34D after 90 minutes of glucose intake. This result shows that the maximum increment in mean accommodation lag occurred at 30 minutes and 60 minutes after which the mean accommodation lag returned to baseline accommodation lag (0.61±0.28D) at 90 minutes. The result among the females showed that the mean accommodation lag at 30, 60 and 90 minutes after glucose intake was at 0.91±0.40D, 0.81±0.51D and 0.70±0.48D respectively. The maximum increment in accommodation lag occurred at 30 minutes after glucose intake after which the accommodation lag returned to baseline accommodation lag 0.58±0.39 D at 90 minutes.

SPSS data analysis using the one-way ANOVA showed that there was a significant difference between the accommodation lag of all subjects before and after 30 and 60 minutes of glucose intake. Nwala et al. [13] considered the effect of glucose on amplitude of accommodation of normoglycemic emmetropes. Their result showed that the effect of glucose on amplitude of accommodation (AA) was only significant ($P<0.05$) 60 minutes after the intake of the glucose. They further stated that the increase in AA was probably due to water retention or hydropic swelling of the crystalline lens in the presence of glucose resulting in increase in refractive index and optical power of the eye. The result of this study showed that accommodation lag before and after 30, 60 and 90 minutes of glucose are not same. This increase in accommodation lag could be due to fluid retention and hydropic swelling of the crystalline lens as a result of increased glucose level in the aqueous and vitreous humor. [14] Due to glucose diffusion through the aqueous into the lens, glucose content in the lens is expected to increase. [15] Exchange of water between the crystalline lens and its surrounding tissues is usually affected by the blood sugar level. Glucose and sodium concentration in the intraocular fluid will result in osmotic hydration of the ocular tissues especially the crystalline lens. [16] Related studies [17-19] have expressed a relationship between glucose intake and accommodative abilities. It is imperative that people monitor their blood sugar levels regularly as changes in the sugar level can affect the accommodative functions.

In conclusion, the glucose intake had a significant effect on the accommodation lag of both males and females below 30 years. Eye care practitioners are advised to monitor the blood glucose values of their patients especially when there are sudden changes in their accommodative functions.

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