Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9291
ISSN on-line: 1807-8648
Doi: 10.4025/actascihealthsci.v37i2.28476

Effectiveness of exclusive self-monitoring of fasting capillary blood glucose in the treatment of diabetes

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ABSTRACT. The study aims to analyze the efficacy of the exclusive self-monitoring of the fasting capillary blood glucose in the control and treatment of diabetic patients. This is a quasi-experimental study, for which five individuals with diabetes were selected, who perform only the fasting capillary blood glucose monitoring, being added about seven other measurements, a variable number according to the individual availability of the volunteer, at different times throughout the day. It was verified that four individuals presented blood glucose values by the use of the fasting capillary blood glucose monitoring, within the parameters of normality for diabetics, between 70-130 mg dL^{-1} of blood (ADA, 2014b), although in the other measurements, they presented values far from the ideal goal, in a significant part of the time. The study outlines a trend that shows that the glycemic monitoring values based solely on the fasting capillary blood glucose is ineffective, since they can erroneously indicate satisfactory control of the blood glucose levels. Based on the results obtained, to a more effective monitoring and which denotes levels of reliability, it is required at least three measurements of capillary blood glucose throughout the day, and also, the importance of long laboratory tests for glycemic monitoring, such as glycated hemoglobin.

Keywords: diabetes mellitus, fasting, blood glucose, blood glucose self-monitoring, efficiency.

Análise da eficácia do automonitoramento exclusivo de glicemia capilar de jejum no tratamento da diabetes

RESUMO. O objetivo deste estudo é analisar a eficácia do automonitoramento exclusivo da glicemia capilar de jejum no controle e no tratamento de pacientes diabéticos. Trata-se de um estudo quase experimental, para o qual foram selecionados cinco indivíduos portadores de diabetes que realizam apenas o monitoramento da glicemia capilar de jejum e acrescentaram cerca de outras sete medições, número variável de acordo com a disponibilidade individual do voluntário, em diferentes horários ao longo do dia. Verificou-se que quatro indivíduos apresentaram os valores glicêmicos pelo monitoramento da glicemia capilar de jejum dentro dos parâmetros de normalidade para os diabéticos, entre 70 – 130 mg dL^{-1} de sangue (ADA, 2014b), apesar de nas outras medições apresentarem, em parte significativa das vezes, valores fora da meta ideal. Logo, o estudo traça uma tendência que mostra que o acompanhamento glicêmico baseado exclusivamente nos valores de glicemia capilar de jejum é ineficaz, uma vez que pode erroneamente indicar controle satisfatório dos níveis glicêmicos. Mediante os resultados obtidos, para um monitoramento mais efetivo e que denote níveis de confiabilidade é necessário de pelo menos três medições de glicemia capilar ao longo do dia e, também, a importância de exames laboratoriais de acompanhamento glicêmico longo, como a hemoglobina glicada.

Palavras-chave: diabetes mellitus, jejum, glicemia, automonitorização da glicemia, eficiência.

Introduction

There are reports on the discovery of diabetes in the year 1500 BC, however only centuries later, in Ancient Greece, the disease was named. In the 19th century it was discovered that there were two types of diabetes, one that affected young people, which seemed more serious, and another that affected adults, diabetes type 2 (SBEM, 2014).

Nowadays, there are more than only two types of Diabetes Mellitus and this illness is considered a group of metabolic diseases characterized by the hyperglycemia resulting from the defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes is related to long-term failure, damage and dysfunction of various organs (ADA, 2005).

The classification of diabetes includes the two main types, type 1 (DM1) and type 2 (DM2), but also includes other specific types of this disease that will be discussed subsequently.

The type 1 is due to β-cell destruction, usually leading to absolute insulin deficiency. This form of diabetes accounts for only 5–10% of those with diabetes. It results from a cellular-mediated autoimmune destruction of β-cells of the pancreas. Usually, this form of diabetes is diagnosed in children and young adults. The DM1 may also be present in older people, and this form is usually called latent autoimmune diabetes of the adult (LADA). However, it is not unanimity that LADA is a form of DM1. Because of the lack of studies of this form of DM1, some researchers believe that LADA is between DM1 and DM2 or even is another type of diabetes. It is important to mention that some forms of DM1 do not have known etiologies. There is, for instance, an idiopathic form that is not related to autoimmunity. The patients who have this form, have permanent insulinopenia and are prone to ketoacidosis. (ADA, 2005; SILVA, 2007)The type 2 diabetes, on the other hand, ranges from predominantly insulin resistant with relative insulin deficiency to predominantly insulin secretory defect with insulin resistance. It is typically diagnosed in midlife and accounts for 90-95% of those with diabetes. There are many causes for this diabetes form such as obesity, which includes abdominal fat, lack of physical activity, advanced age, depression. Contrary to what occurs in the manifestation of DM1, the symptoms of DM2 are silent in the initial stage. In this case, the hyperglycemia develops gradually and, at the beginning of the disease, the patient does not notice any significant symptoms. However, irreversible complications may develop before beginning of treatment (ADA, 2005; INZUCCHI 2012; DEFRONZO et al 2015).Another common type of diabetes is the gestational diabetes mellitus (GDM) which is defined as any degree of glucose intolerance with onset or first recognition during pregnancy. This definition applies even if the condition persists after pregnancy. The prevalence may range from 1 to 14% of the pregnancies, depending on the population studied. This condition is associated with adverse pregnancy outcomes, including fetal macrosomia, stillbirth, neonatal metabolic disturbances, and related problems. Moreover, offspring of mothers with GDM are at increased risk for diabetes and obesity and women with GDM are more likely to develop diabetes in the years following pregnancy (COUSTAN, 2013).

In addition to the above-mentioned diabetes types, there are other specific types of diabetes. Maturity-onset diabetes of the young (MODY) is a group of clinically heterogeneous forms of β-cell dysfunction that are defined at the molecular genetic level by mutations in different genes. These forms of diabetes are usually diagnosed before 25 years of age. They are characterized by impaired insulin secretion with minimum or without defects in the insulin action. They are inherited in an autosomal dominant pattern (ADA, 2005; SHIELDS et al., 2010).

There are, also, unusual causes of diabetes that result from genetically determined abnormalities of the insulin action. This, associated with mutations of the insulin receptor may cause severe diabetes (ADA, 2005).

Moreover, process that injures the pancreas, such as trauma, cancer and pancreatitis may cause diabetes, as well as excessive amounts of hormones that antagonize insulin action, for instance, growth hormone, cortisol, glucagon and epinephrine. In addition, it is important to mention that many drugs, for instance, glucocorticoids, can impair insulin secretion. Therefore, although these drugs do not cause directly the diabetes, they may precipitate the disease (ADA, 2005; LANSANG, HUSTAK, 2011).

In addition, it is relevant to mention that some infections and syndromes can be related to diabetes mellitus because besides they can cause the disease, they can increase the morbimortality of diabetes (ADA, 2005; CASQUEIRO et al., 2012).

Therefore, although there are many causes, in short, diabetes mellitus is a chronic illness that requires multifactorial risk reduction strategies besides glycemic control and in which one of these strategies is the self-monitoring of glycaemia (ADA, 2015).

In Brazil, there are about 13 million people affected by DM2, and the glucose monitoring is important to assess the capillary blood glucose through the glucometer, and through tape reagents. Such equipment are provided by SUS, however only upon availability (SBD, 2014; BRASIL, 2007).

In this sense, since a significant portion of the Brazilian population uses only the blood glucose fasting as self-monitoring for diabetes, it is questioned therefore, the actual effectiveness of this approach as a unique method for the monitoring. Thus, the study aims to analyze the efficacy of the exclusive self-monitoring of the fasting capillary blood glucose in the control and treatment of diabetic patients.

Material and methods

This is a quasi-experimental study that was conducted in the municipality of Alfenas, Minas

Gerais State, from April to October 2014. The Protocol was approved by the Research Ethics Committee of the University of José do Rosário Vellano (Unifenas - Campus of Alfenas), and all participants signed an informed consent form.

The participants were selected according to the availability of the researcher, since not all guests accepted to participate in the study. Individuals with diabetes were addressed to health units of basic attention in Alfenas, Minas Gerais State, assisted by researchers with pre-established inclusion criteria. No random sample technique was used due to the very nature of the research. Preferably, volunteers selected were those who already made regular use of a glucometer and blood glucose strips.

Each patient held, on average, eight capillary blood glucose monitoring throughout the day, including fasting capillary glycaemia, for about seven days. The number of glucose measurements ranged according to the routine of each volunteer presented in Table 1.

Table 1. Blood glucose measurements schedule during the day.

Fasting	2h after breakfast	Before lunch	2h after lunch	Before dinner	2h after dinner	bedtime	3:00 am.

In order to prevent changes in the behavior of volunteers during the period of analysis, recent examinations of glycated hemoglobin (Hb1ac) were collected, in addition, each patient described all its daily diet.

It is worth mentioning that the reason for the sample being small, favored the accompaniment and individual analysis of each volunteer by the researchers.

Results and discussion

Due to the small sample size, the results could not be generalized, however, relevant trends can be verified, which were observed through daily measurements made in the participants in relation to the glucose behavior.

It can be seen in Figure 1 that 69% of the measurements presented fasting blood glucose as normal, and 31% had blood glucose values altered.

When analyzing the Glycemic values of 5 participants in other times of the day, in days when fasting blood glucose was normal, it was found, as shown in Figure 2, that 88% of the measurements presented changed values and 12% had blood glucose values considered normal.

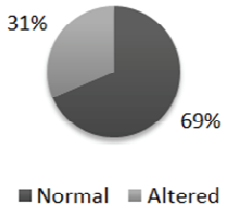

Figure 1. Total percentage of measurements in which the values of fasting glucose were normal or altered, corresponding to 24 days with normal and 11 days with altered fasting glucose.

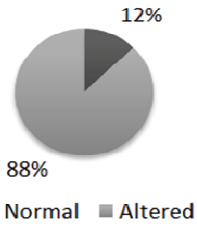

Figure 2. Percentage of measurements in which the blood glucose presented normal values.

According to the information presented in Figure 3, obtained through the average measurements made over a week in participants who were fasting, as well as, in different times of the day, it can be observed that the Glycemic values were similar and within the acceptable parameter, 70-130 mg dL^{-1} pre-prandial of blood for the 4 participants, on an empty stomach. By evaluating the blood glucose at other times, in general, it is noticed that the glycemic values often are beyond the acceptable parameter, the postprandial is less than 180 mg dL^{-1} of blood (ADA, 2014b).

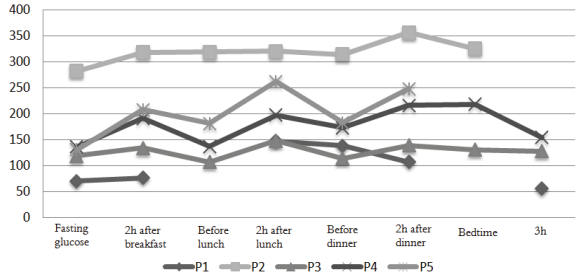

Figure 3. Glycemic behavior of the participants evaluated during a week.

An important fact to be mentioned is that, all participants, except for the P2, which is depressive, had a restrictive diet, which contains limited amounts of carbohydrates and protein. However, not all completely adhered to the treatment.

In addition, it is important to mention that, except for the P3, all other participants had glycated hemoglobin levels above the recommended for

diabetics. It is worth noting that this laboratory test is not part of the routine of these patients.

For an effective glycemic control treatment, the self-care should include medicines, proper nutrition, exercises, glycemic monitoring and health education. In none of the cases accompanied, such steps were completely followed, only the medicinal approach was mostly practiced (ADA, 2014c).

This, therefore, reflects the glycemic behavior of the participants. Only the P3, who although being sedentary, shows up with blood glucose levels within the expected target for a diabetic patient in effective therapy. On the other hand, the other participants had inefficient therapy, or, nor even joined the proposed therapy, which implies in a broader therapeutic approach, not only medication.

As part of an approach that tends to contribute to the effectiveness of the proposed treatment, health education is based on the approach of the health professional when dealing with the patient, taking into account, beliefs, social class, gender, and age, that is, identifying the patient as being a biopsychosocial being. Moreover, this is of great value in the formulation and monitoring of a therapy (GAZZINELLI et al., 2005).

An important fact to report is that the diagnosis of the disease can be, at least in the beginning, a complicating factor to the adherence in the treatment. The American Diabetes Association-ADA (2014a) states that, upon being informed of the diabetes, patients often feel lost, scared, stressed, angry, shocked, guilty, discredited and without the will to think about the disease. All these feelings are going against the effectiveness of the treatment and are covered by the health education, so they must be sympathetically considered by the physician in order to enhance the adherence to the treatment.

These above-mentioned sensations were reported by the P4, who, despite having already been diagnosed for over ten years, still feels angst and insecurity about the diagnosis.

Besides the inadequate control of the blood glucose, mainly after fasting, it was also observed peak of hypoglycemia in the P1. This effect may be related to the intake of rapid absorption carbohydrates, which causes hyperglycemia, and, in a reactive way, hypoglycemia. Thus, the diabetic does not need to give up the carbohydrates. It is advisable, in fact, that diabetics reevaluate the quality of the ingested carbohydrate, replacing high glycemic carbohydrates for those with a low glycemic index, which gives feeling of satiety and slows down the absorption of food, due to the stimulation of hormones, such as, cholecystokinin and peptide 1, a glucagon-like hormone. This recommendation is valid not only to those who possess hypoglycemic clinical condition, but to all diabetics (SARTORELLI; CARDOSO, 2006).

It is worth noting that the adherence to the glycemic control has strong influence of the behavioral state of the diabetic. This was noticed in the glycemic behavior of the P2, which proved to be far above the desired values. The depression of the P2 and concomitant comorbidity tend to compromise the quality of life, including physical and psychological health, social relationships, environmental domain, as well as, social pressure, which are related to the general health of diabetic. A fact that hinders the daily adherence of the patient. Furthermore, the amplification of the disease symptomatology can occur (FRAGUAS et al., 2009).

In general, as for the treatment and control of DM2, changes in behavior in relation to diet, intake of medicines and in lifestyle is required. It is important to notice that a programmed eating habit is one of the pillars in the treatment of diabetes. Furthermore, in many cases, only this treatment associated with physical exercises are the only therapeutic measures (DURAN AGUERO et al., 2012).

Medicated resources are employed, usually in a second moment of the therapy, when there is inability to control glucose levels, preferably through the practice of diet and physical exercises (SANTOS et al., 2012).

In addition, as a form of keeping track of glucose levels, the self-monitoring of capillary glucose is indicated for every patient treated with insulin, or oral anti-hyperglicemic agents. The optimal achievement of frequency tests of capillary glycemia is not defined for patients with DM2, because it depends on the type of treatment carried out, oral agents, or insulin, and the stability of the metabolic clinical status. The measures of postprandial glucose may be useful to evaluate the metabolic control while the values of Hb1ac are increased in the presence of appropriate values of preprandial glucose (SARTORELLI, CARDOSO, 2006).

The treatment of diabetes aims at maintaining the metabolic control and, basically, comprises a non-drug and drug therapy, the first is related to the behavioral changes associated with the healthy eating and physical activities. The nutritional therapy, based on the orientation and establishment of an individualized nutrition plan, coupled with physical exercise, is considered the first-line therapy for the control of diabetes , and its benefits are documented in the literature (BOAS et al., 2011).

Regarding the diabetic diet, it is important to stress that it should be individualized according to

daily caloric needs, level of physical activity, and dietary habits of the patient. In addition, it is worth noting that around 85 or 90% of the patients with DM2 are obese. Therefore, for a balanced diet, it is important to decrease the daily calories ingested from 15 to 30%, or more. With such conduct, it is possible to reduce three risk factors for cardiovascular disease, which are obesity, Dyslipidemia (present in about one-third of diabetics) and hypertension. A low-calorie diet improves insulin sensitivity and reduces hyperglycemia, independent on the weight loss (ARAUJO et al., 2000).

Moreover, physical exercise is considered one of the cornerstones of both prevention and treatment of individuals with DM2. It is known that it improves insulin sensitivity, decreases hyperinsulinemia, increases muscle glucose uptake, improves lipid profile and hypertension, and improves physical and mental sense of well-being. In addition, it can contribute to weight loss (SARTORELLI, CARDOSO, 2006; ARAUJO et al., 2000).

Studies have shown that the reduction of body weight, associated with increased physical activity in individuals with increased risk for developing diabetes reduces in 58% the incidence of this disease (PAULI, et al., 2009),

However, exercises should be done with careful evaluation, considering the presence of macro and microvascular complications in the patient, in order to define the most appropriate types of exercises if neuropathy, nephropathy and/or retinopathy are present (ARAUJO et al., 2000).

Regarding medication, there are several pharmacological options, which can be used individually or in association, such as insulin action sensitisers (metformin, thiazolidinediones), anti-hyperglicemic agents (acarbose), secretagogues (sulfonylureas, repaglinide, nateglinide), anti-obesity drugs and/or insulin (ARAUJO et al., 2000).

Nonetheless, Khan (2003), showed that there is a progressive worsening of the pancreatic β-cell function, regardless of the type of pharmacological treatment, and that, after nine years of treatment only 25% of diabetics continue to respond to monotherapy, being required the association of multiple resources for better glycemic control.

In addition to these therapeutic options, it is important to raise diabetics' awareness of their participation in the glycemic control of diabetes, especially for capillary blood glucose, and on how to proceed in situations of hyper or hypoglycemia, infections, and during pregnancy. This improves diabetes control and decreases the frequency of hospitalizations (ARAUJO et al., 2000).

In this sense, it is noticed that the failure of monitoring in the primary care causes, therefore, an overload in the tertiary care. A study of patients with DM2, clinically assisted, showed that hypertensive heart disease was present in 36% of them and peripheral vascular disease in 33%. Among the microvascular complications, 37% had kidney disease and 48% had diabetic retinopathy (proliferative retinopathy was 15%). Distal sensory neuropathy was found in 36% of these patients and 73% presented hypertension. The cholesterol was above 200 mg dL^{-1} in 64%, while 36% had the BMI > 30 kg m^{-2} (SCHEFFEL, 2004). These data were studied in the last few years, thus confirming the need for a monitoring of quality.

Therefore, today, among the health programs that are being developed in Brazil, there is the Glucometers and Supplies Dispensation for Blood Glucose Self-Monitoring Programme for individuals with Diabetes Mellitus. The implementation of the programme occurred after the approval of the Brazilian Federal Law No. 11,347/2006, making mandatory the free availability of materials such as blood glucose meter and test strips for measuring the blood glucose. Also, lancets for fingerstick, in which the individuals with diabetes type1 (DM1) and type 2 diabetes (DM2) use to perform the self-monitoring of insulin at home (AUGUSTO et al., 2014).

The self-monitoring of blood glucose at home provided, to all patients studied in this research, the development of skills for autonomy and decision-making in order to achieve the goals of good glycemic control, reduction of acute and chronic complications and, consequently, better quality of life for the individuals with DM. This technology of care is recommended as an essential part of treatment strategies for adequate control of DM (AUGUSTO et al., 2014). However, despite the benefits presented by the programme, it is not a simple process.

Some aspects concerning the use of the devices can negatively affect the adherence to this technology, especially the presence of pain at the injection sites, lack of skills in the management of the monitors and possible problems with the reliability of the results. By accession, it is understood that, rather than following recommendations, it is assumed that relationship and bond, in the case of a multifactorial process with structured partnership for caregivers and those who are cared for, refer to the frequency and consistency in the implementation of care.

Although studies show that the severity of the disease can be a contributing factor for the

adherence to the self-care, it is recognized that even for serious diseases, the non-adherence is universal to a certain degree. The non-adherence to treatment of chronic diseases, in particular, is estimated to reach 50% or more (BOAS et al., 2011).

The Brazilian Society of Diabetes in 2009, introduced new standards and cutoffs for monitoring and tracking the individual with diabetes: increased A1C parameter to < 7% in adults and changed the minimum and maximum values for fasting glucose and postprandial from 110 mg dL^{-1} to 130 mg dL^{-1}; and from 140 mg dL^{-1} to 180 mg dL^{-1} respectively.

The Canadian Diabetes Association, in 1998 and 2001, recommended, among other actions, the examination of A1C every 2-4 months and of SMBG at least four times a day for individuals with diabetes using insulin, similar frequency for the currently recommended by the Ministry of Health (MOH) in Brazil. The SMBG is highly accurate, showing exactly the glycemic values, enabling therapeutic interventions and helping to reduce the HbA1c values. A study conducted in Canada and in the United States for individuals with type 1 DM identified 76% of reduction in the risk of developing primary retinopathy, 54% of individuals with slowed progression of retinopathy, 35% of reduction in microalbuminuria and 60% of clinical neuropathy, with the implementation of the blood glucose self-monitoring programme. However, it is worth noting that, through the individuals assisted, it is believed that as well as these individuals, other people with diabetes do not follow correctly the guidance, a fact that occurred among the participants of this project.

The lifestyle changes represent great difficulty for people. Particularly, people with diabetes must make daily decisions to control their disease and, these decisions have considerable impact on their well-being, more than those decisions taken by health professionals. However, treatments that require personal decision or judgment are strongly associated with noncompliance. In addition, personal beliefs on nutrition, particularly concerning the existence of harmful or forbidden foods, are difficult to change, becoming taboos that can interfere with the adherence to self-care (BOAS et al., 2011).

In Brazil, the Ministry of health ensures with the Health Legislation System that the self-monitoring of the capillary blood glucose must be integrated to the therapeutic process, and most of all, to the autonomous development of the carrier for the self-care through health education. It should be continuously offered to patients, selected according to personal circumstances and clinical picture, and these should receive continued team support to ensure the effectiveness of the process. In addition, the use of measuring instruments, (glucometers) and reagent strips, must be individualized and meet the needs of the patient, being the recommended daily frequency, on average, from three to four times a day (BRASIL, 2007).

It is worth mentioning that all participants reported difficulties of access to these two cited materials. The reagent strips were distributed only to participants who made use of insulin, by the health committee in the city, where the project was carried out, however, the amount was insufficient for two daily measurements. Participants who did not receive insulin, had no access to these materials, since the availability, according to the participants, was low and restricted, as it was said to those who did not receive the insulin. Therefore, participants generally had limitations in the control of diabetes, being forced, sometimes, to measure the blood glucose only once a day, being the preferred choice, in fasting. This, as it will be discussed below, is not the ideal monitoring.

Conclusion

It can be seen a trend that shows the fasting capillary blood glucose as an insufficient exclusive self-monitoring. This leads to the conclusion that there may be many patients, who wrongly believe they have an effective therapy, because this is based on a single value.

This situation, coupled with the fact that the disease is frequently silent, make it possible to deduce that, a person with diabetes who believes to be with proper blood glucose level will not maintain a lifestyle to match with the reality of the health and will prevent other types of more accurate examinations.

As a result, the disease can progress to a more severe stage, achieving organs such as kidney, eye and heart and result in increased morbimortality. Thus, the diabetic can become dependent on others, in both senses, locomotor and financial, for instance. This, in turn, can cause economic problems for a family, and has the potential to produce psychological problems for the diabetic, such as depression.

Moreover, the results of this research reinforce the importance of long-term monitoring tests, as glycated hemoglobin, since this test is more reliable because it denotes accurate values and covers a long period of time.

In this way, it is possible to realize the importance of an effective primary health, because if

the primary care is successful, there will be no overload of specialized care. Also, financially it is advantageous that the primary care is well done, since that, besides the costs of the primary health care to be lower, it prevents the diabetic patient of developing a stage of economic unproductivity. Then, it is important that the healthcare system focuses on the primary care.

In addition, it can be inferred that patients still lack correct orientation from the health care professionals and importance of a continuous monitoring. It is also worth noting that, the absence of other types of monitoring test, such as glycated hemoglobin, and the insecurity and irregularity in delivering materials can contribute to an imperfect monitoring.

Therefore, it is evident the damage that the hyperglycemia, maintained quietly, can cause to body, psychological behavior and economy. In this way, these data support the conclusion that the blood glucose control should not be based solely on data collected through the blood glucose levels in fasting capillary blood, once these data do not denote levels of reliability. Therefore, these values should not be considered separately.

Acknowledgements

First, we thank God for granting us the possibility to carry out this research; we also thank the University and the faculty members for the great support and assistance; the FAPEMIG, which permitted to carry out this endeavor; the advisers in this project, professors Alessandra and Ciderleia. In particular, we thank our professor Roberta, who helped us in relation to data structure; the volunteers who agreed to take part of this research; and finally, to our parents, for their love, encouragement and unconditional support.

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Received on July 9, 2015.
Accepted on September 14, 2015.