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Factors Affecting Diabetes Type-1 Based On Individuality And Self-care Evaluation

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Abstract

Despite the increasing number of diabetic patients, self-care plays an important role in the prevention and detection of various complications such as neurological disorders. The aim of this experiment was to investigate the main factors affecting diabetes type 1 and self-care. For this purpose, six volunteer subjects with diabetes type 1 were included. Their glucose levels together with the carbohydrate intake and other factors were recorded four times a day for 30 days. In order to perform statistical analysis, the one-way variance analysis, Pearson correlation coefficient, time series analysis, and the combined time series (panel) analysis were applied. The findings of this study demonstrated that the alteration in blood glucose levels was strongly influenced by carbohydrate intake, physical activity, stress level, amount of sleep, and insulin; while slightly influenced by pills and supplements use, hypoglycemia, insulin sensitivity, alcohol and cigarette use, and comorbidity. In four patients, the self-care score was normal, one patient exhibited high level and the reaming showed low level. For each patient, the error rate was as follows: 6.451, 6.095, 8.819, 7.368, 6.05, 5.856. Regarding to the loss of HbA1c rate after our study, people are advised to control their blood glucose levels based on individual preferences, conditions, lifestyle, and physiology for preventing severe diabetes type 1 conditions and extra cost.

INTRODUCTION

Diabetes is a chronic disease affecting a growing number of people. There are over 425 million diabetic patients worldwide. According to statistics, diabetes caused around USD 727 billion of health expenditure in 2017 [1]. The disease itself results in a variety of complications including heart diseases, neurological disorders, eye-related problems, and amputation. It also causes high expenditures for both patients and health care organizations [2]. Keeping blood glucose level at the normal range is the only way to control the disease. Many factors have been found to affect the blood glucose level. Since these factors have various affecting coefficients in different individuals, it is logical to determine them for the purpose of disease management, control, expenditure decrease, and improvement health care quality. According to the literature, self-care has been regarded by many physicians and health specialists as a process through which patients learn to monitor their diet, clinical treatment, blood glucose, and physical activities and to promote their life quality [3, 4]. As the finishing statement, the current study aimed to recognize factors affecting blood glucose, as well as to provide a prediction model for each patient by which the self-care criteria could be evaluated.

METHODS

Participants and Material

In the present study, the blood-glucose-affecting factors were found according to articles and the viewpoint of experts. The reliability and validity of the designed questionnaire were confirmed by academic and professional individuals. Six volunteer subjects with diabetes type 1, ranged from 12 to 38 years of age, with the basic academic knowledge were included with their own consent. Following training and education in self-care, the subjects were provided with a glucometer and a questionnaire to record their glucose levels and affecting factors such as carbohydrate intake, physical activities, stress level, amount of sleep, alcohol use, cigarette use, pills, and supplements, as well as insulin, hypoglycemia, comorbidity, and insulin sensitivity. Each candidate had to undergo an HbA1c test before and after the experiment. The candidates recorded their activities

four times a day (morning, noon, evening, and night) for 30 days. The collected data was entered into Excel to perform one-way variance analysis, Pearson correlation coefficient, combined time series, and the time series analysis (panel analysis). R, SPSS, and EVIEWS programs were employed to predict and perform various assessments. Finally, a prediction model for blood glucose level, containing error rates (with MSE and MAE), coefficients, and self-care grades, was obtained for individuals.

Data Panel Regression Models

Generally, the changes of a variable (y) have been explained based on some of the variables (Xs) in these models. In this research paper, the following function was used:

$$y_i = f(x_{ki}); \quad k = 1,2,\dots,K; \quad i = 1,2,\dots N \qquad (1)$$

In which "k" is the number of explaining variables. To begin, this function was considered linear as follows:

$$y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + \varepsilon_{it} \qquad (2)$$

In this function, "i" is the number of observations for each variable. The number of observations can be a time-based process. In this case, we have "y_t" and "x_{kt}" which were measured during the year, season, and month for each variable. Furthermore, there will be t=1, 2…., T; on the other hand, yt and xkt are time series. In the regression approach, the time vectors of individuals were stacked in one vector. The aforementioned models were predicted to find βs or the function's coefficients. The statistical analysis for the coefficients, regression validity, and the regression F and R2 depends on the number of observations (T for the time series, N for the section data) and the number of predicted parameters (βs) [5].

Prediction Accuracy

The prediction error is considered as the difference between the real and the predicted value during the observation period. If we consider E as the prediction error, Y as the real value, and F as the predicted value, then the prediction error, according to the following relation, will be:

$$E_t = Y_t - F_t \qquad (3)$$

The mean absolute error (MAE) and the mean of square error (MSE) are the two assessment index adopted in this study. The MAE is obtained from the following relation:

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |Obs_i - For_i| \qquad (4)$$

In addition, the MSE is obtained from the following relation:

$$MSE = \frac{1}{n}\sum_{i=1}^{n} (Obs_i - For_i)^2 \qquad (5)$$

In the above-mentioned relation, Obs_i and For_i are the orders of observational and predicted values, respectively. Moreover, n is the total number of the observational data [6].

RESULTS

The validity of the questionnaire was approved. In addition, the reliability of the results was evaluated by Cronbach's alpha at 87%. The affecting coefficient for blood glucose was obtained by panel regression technique and is demonstrated in the following Figure and Table (Fig 1 and Table 1).

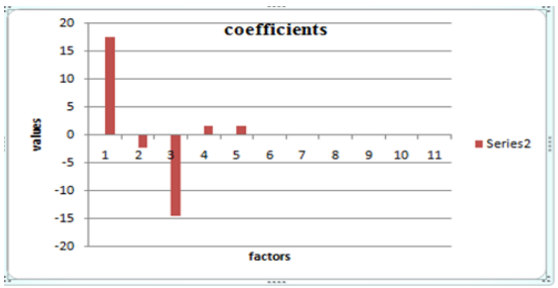

Figure 1: The Affecting Coefficient of Influential Factors by the Panel Regression Technique

Table 1: The Panel-based Results of the Prediction Model

Aspect	Variable	Coefficient	Statistical t
	Fixed variables	14.5	26.01
1	Carbohydrate intake	17.715	18.48
2	Physical activity	-2.33	66.13
3	Insulin	-14.58	39.32
4	Amount of sleep	1.46	76.69
5	Stress level	1.53	66.27
6	Comorbidity	0.058	6.65
7	Pill and supplement use	0.07	7.14
8	Alcohol and cigarette use	0.016	3.48
9	Insulin sensitivity	0.025	4.27
10	Hypoglycemia	0.067	7.14
	Regression statistics	R=90%, F=60.71	P value=0.00

Our findings revealed that the variables of carbohydrate intake, amount of sleep, stress level, comorbidity, pill and supplement use, alcohol and cigarette use, insulin sensitivity, and hypoglycemia are directly associated with blood glucose fluctuation and can be predicted from the positive coefficients. On the other hand, insulin and physical activity are reversely linked to blood glucose alterations and can be predicted from the negative coefficients. Our findings demonstrated that the blood glucose level was remarkably affected by carbohydrate intake, physical activity, stress levels, amount of sleep, and insulin. On the other side, blood glucose was slightly influenced by pills and supplements use, hypoglycemia, insulin sensitivity, alcohol and cigarette use, and comorbidity. The prediction error (3), (4), (5) for each patient is shown in the following Table (Table 2).

As demonstrated in Table 2, the prediction of blood glucose fluctuation for each patient has accurately been obtained using this technique. In addition to other variables, consideration of the previous blood glucose level of each patient was found to reduce the prediction error. The self-care aspects of the patients are shown in Table 3. The results of self-care assessment for each factor, each patient, and each time of the day are demonstrated in Table 4.

According to the results demonstrated in the Table 4, the self-care level was reported as very good for four patients, good for one patient, and poor for another patient, respectively. The lowest level of self-care was for the aspects 1 and 2 (following diet plans and blood glucose control); while the highest one was found for the aspects 7 and 8 (non-consumption of alcohol and cigarettes and control of hypoglycemia). The results of self-care for the four times of the day are demonstrated in Table 5.

As shown in Table 5, no significant difference was found among the results of self-care for the four times of the day. In accordance with Pearson correlation coefficient ($P = 0.035$, $r = 0.842$), the findings of other studies are in agreement with the patients' A1C hemoglobin test or HbA1c results, revealing a fall in the HbA1c level compared to the past.

Table 2: The Prediction Error for Each Patient

Patient	MAE without prior blood glucose	MSE without prior blood glucose	MAE with prior blood glucose	MSE with prior blood glucose
1	6.451	47.077	6.429	46.68
2	6.095	44.736	6.07	44.22
3	8.819	9.671	8.599	88.982
4	7.368	74.284	7.338	72.382
5	6.050	38.339	6.039	38.231
6	5.856	36.036	5.779	35.281

Table 3: The Self-care Aspect of the Patients

Aspect	Description
1	Following the diet plans
2	Blood glucose control
3	Regular drug consumption
4	Doing physical activities
5	Control of stress level
6	Control of Sleep
7	Non-consumption of alcohol and cigarettes
8	Control of hypoglycemia

Table 4: The average and Standard Deviation of the Self-care Aspects for Each Patient

	Aspect 1	Aspect 2	Aspect 3	Aspect 4	Aspect 6	Aspect 7	Aspect 8	Total score
Patient 1	4.25 ± 6.17	7.33 ± 4.44	6.25 ± 4.86	16.66 ± 5.39	7.66 ± 4.24	10 ± 0	9.5 ± 2.18	66.98 ± 32.28
Patient 2	12.5 ± 3.32	3.91 ± 4.9	5 ± 5	6.67 ± 9.47	5.67 ± 4.98	10 ± 0	8.5 ± 3.59	62.25 ± 31.26
Patient 3	2.08 ± 407.	16.67 ± 3.74	5 ± 5.02	17 ± 6.13	4 ± 4.91	9.67 ± 1.80	9.34 ± 2.5	66.09 ± 33.17
Patient 4	3.08 ± 5.30	2.67 ± 4.44	5 ± 5.02	10.33 ± 4.09	0.3 ± 1.8	10 ± 0	8.08 ± 3.95	39.46 ± 29.59
Patient 5	3.42 ± 5.42	7.67 ± 4.25	8.5 ± 3.59	17.67 ± 6.18	8.67 ± 3.41	10 ± 0	5.34 ± 5	70.27 ± 30.86
Patient 6	408. ± 7.04	5.83 ± 4.95	7.58 ± 4.30	6.67 ± 7.48	7.67 ± 4.25	10 ± 0	8.33 ± 3.74	57.49 ± 36.2

Table 5: The Average and Standard Deviation of the Self-care Aspects for each Time of the Day

	Aspect 1	Aspect 2	Aspect 3	Aspect 4	Aspect 5	Aspect 6	Aspect 7	Aspect 8
Morning	4.44 ± 6.55	12 ± 8	3.33 ± 4.73	10 ± 0	5.67±4.97	6.89±4.64	10±0	8.39±3.69
Noon	3.03 ± 5.59	11.93 ± 8.07	6.3 ± 4.84	4.03 ± 4.92	5.7±4.97	6.9±4.66	9.95±0.7	8.23±3.83
Evening	6.25 ± 2.65	11.93 ± 7.98	4.66 ± 5	3.52 ± 4.79	5.57±4.98	6.81±4.67	10±0	8.13±3.91
Night	3.31 ± 5.48	11.99 ± 7.99	5.02 ± 5.01	7.24 ± 4.48	5.69±4.97	6.91±4.64	9.83±1.28	8.12±3.92

*P-value: 0.637

CONCLUSIONS

In this study, the affecting coefficient of influential factors on blood glucose fluctuations was determined by providing a prediction model for each patient, then the self-care score of each one was reported. The present study provided better results compared to the study which was conducted in 2013 by Eleni et al. using the SVR technique with blood glucose, insulin, carbohydrate, and physical activities parameters [7, 8]. Our paper also demonstrated more remarkable output compared to those studies that used AR and ARMA

techniques only with blood glucose as parameters. Furthermore, better findings were obtained in our research in comparison to the study by Stah et al. in 2009 using Arma and Armax techniques with blood glucose, insulin, and carbohydrate parameters [7].

The output of the present study was similar to Jabali's evaluation in terms of the number of patients which was conducted in 2013 using ARM technique with blood glucose, insulin, food intake, and physical activity parameters on an individual basis. However, they were different in terms of input parameters to the model. In addition to the aforementioned case parameters, our study also included cigarette use, insulin sensitivity, diagnosis with other diseases, supplement use, hypoglycemia, amount of sleep, and stress level. In terms of the patients' prediction error results, though the patients of our study were in the same range, the results demonstrated both high and low level of error among the them [9]. Additionally, there was a high level of error in our study compared to Najma and Bahamir's study of 2014 which was conducted by the combination of petri and phase network and the use of blood glucose, BMI, and insulin parameters [10]. The use of diverse input variables in this study is a potential reason for this high level of error. According to the literature, in the self-care aspects, [11, 12] weak level of the diet, medicine, and physical activities were reported, while the blood glucose control was regarded to be in as good. The findings of other investigators support the idea that [13, 14] education plays an influential role in self-care improvement. After the detection of affecting factors, the process of self-care was assessed in the present study. It seems that the difference in self-care situations in different studies are due to the difference in patients' knowledge and self-care management techniques as well as ignored affecting coefficient for each factor in patients.

Ethical Issues

In order to comply with ethical principles, the Committee of Medical Ethics was considered (No.52D/749) under the IR.TMU.REC.1394.127 approval document. All the 6 patients participating in the study signed a written consent.

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