Study of Serum Vitamin Profiles in Diabetes Mellitus Patients by using Artificial Neural Networks in a District, Andhra Pradesh, India

J.Balaji Chandra Mouli1, D.S.R.S. Prakash2, S. Murali Mohan3

Department of Biotechnology, Adikavi Nannaya University, Rajahmundry 533 296, Andhra Pradesh, India

Abstract: Diabetes mellitus is a universally prevalent disorder leading to death rooted from various issues of which under nourishment is a major reason in which Micronutrients have been investigated as potential preventive and treatment agents for both type 1 and type 2 diabetes and for common complications of diabetes. At this point, we focused to analyze methodological differences in the profiles of both fat-soluble vitamins and water soluble vitamin in patients with diabetes mellitus from urban and rural areas to know the possible role of these substance(s) in the pathogenesis of diabetes mellitus and an attempt has been done to optimize the serum vitamin concentrations. In both male and female subjects of vitamin supplemented group, slightly lower concentrations of vitamins A, E, C, B6, B12, and B12 were observed when compared to the control group. By using ANN, the vitamins showing the maximum decline effect on the A and E.

Keywords: Diabetes Mellitus, Vitamins concentrations, Artificial Neural Networks, Andhra Pradesh

1. Introduction

Diabetes is the most prevalent endocrine disorder in the world. The total estimated number of people with diabetes worldwide is 347 million. WHO predicts that diabetes would emerge as seventh leading cause of death by 2030. It is a multi-factorial complex disease which is caused due to genetic and environmental factors of which malnutrition has been suggested as one of the major causes of diabetes mellitus in certain geographic areas. More than 80% of total diabetes deaths are estimated to happen in countries with low and middle income.

Over the last 20 years, numerous studies have found alterations in micronutrient status of patients with diabetes mellitus, and in some studies deficiency of certain minerals or vitamins is correlated with presence of diabetic complications. However, these findings have not been comprehensively evaluated. In view of this, depending upon the essentiality of vitamins especially in human body; it is proposed to understand their profiles in diabetic populations But many studies have verified the status of individual vitamins in a particular disease condition.

At this point, we focused to analyze methodological differences in the profiles of both fat-soluble vitamins A (Retinol), D (Cholecalciferol), E (α-Tocopherol) and K (Menaquinone) and water soluble vitamin C and B-complex vitamins: B1 (Thiamin), B2 (Riboflavin), B3 (Nicotinic acid), B6 (Pyridoxine), B9 (Folic acid) and B12 (Cyanocobalamin) in patients with diabetes mellitus from urban and rural areas to know the possible role of these substance(s) in the pathogenesis of diabetes mellitus and an attempt has been done to optimize the serum vitamin concentrations. The key factor to optimize a process is to understand the system’s dynamics which can be obtained by using an accurate mathematical model i.e., non-linear statistical data modeling tool, Artificial Neural Networks (ANN). In previous studies, authors developed various statistical models to evaluate the vitamin status and noticed that the complexity of vitamin levels in the body in diverse pathological conditions was not well understood due to their inadequate accuracies. To overcome this drawback, a methodology based on ANN was adopted.

These days, usage of ANN is becoming popular in the research field especially in medical and clinical research. ANN offers a new dimension for this study, due to its unique advantages such as non-linearity complex behavior and ability to model poorly understood biological systems. It is suitable for optimizing the exact study of systems from all points of view, without performing additional experiments. With the remarkable ability to derive meaning from complicated or imprecise data, ANN can be used to extract patterns and detect trends that are too complex to be noticed by either humans or insilico methods. Development of suitable models, allows optimization and implementation in the process which is highly desirable.

2. Materials and Methods

In the present study, two groups of diabetic subjects from urban and rural areas of about 42 sample was taken from East Godavari district, AP, India were selected where one group was Supplemented Group (SG) that received one multivitamin capsule per day under medical supervision while the other group was Non supplemented group (NSG) that did not receive any supplementation. Non-diabetic subjects from same geographical area were considered as Control group (CG) and their physical, personal and clinical parameters details were recorded.

Blood samples (2 mL) were collected under medical supervision from the subjects with an informed consent at diabetic care unit, GSL general hospital, Rajahmundry, AP, India.
3. Results and Discussion

Subjects with diabetes mellitus having age between 50 – 60 yrs were considered for this study. The baseline data on physical and clinical characteristics among subjects did not show significant differences. The serum vitamin concentrations of subjects with the diabetes mellitus were presented in Table 1. Gender-wise differences were not found with respect to the concentrations of vitamin A, E, K and B-Complex. However, measurable differences were observed in case of vitamin D and C concentrations. This study was initiated to compare the vitamin (A, D, E, K, C, B1, B2, B6, B9 and B12) levels in diabetic subjects of vitamin supplemented group (SG) and non-supplemented group (NSG) with non-diabetic subjects of control group (CG). In both male and female subjects of vitamin supplemented group, slightly lower concentrations of vitamins A, E, C, B1, B2, B6 and B12 were observed when compared to the control group. In case of non supplemented group subjects, very low concentrations of A, E, C, B2, B6 and B12 vitamins were observed when compared to subjects of control group as well as supplemented group. Thus, the above vitamins were found to be low in diabetic subjects. Diabetes appears to have great effect on the decline of vitamin concentrations. Vitamin supplementation under medical supervision could have prevented sharp fall in the vitamin concentrations.

The observed vitamin profile of all subjects was fed as input to the artificial neural network. The network used in this study is fully connected, feed forward and supervised network with back propagation learning rule which is an excellent network for prediction and classification tasks. Here, the input variables were age, disease condition (0 - 3)
and concentration of vitamins. All three parameter groups are considered as three different single data set points. All the data points were used during training, weights and biases were adjusted to minimize the error. While the network was been optimized, the testing data evaluates the trained network. This process was repeated till the maximum number of fixed epochs or minimum root mean squared error was reached. Then the predicted values of the vitamin concentrations of all the sets of data points were obtained as output of the network.

The coefficient of determination ($R^2$) was used as a measure of the predictive ability of the network and gives an evidence for a satisfactory correlation between the inputs and the predicted outputs. Decision on the optimum topology was based on the minimum error of testing. Each topology was repeated five times to avoid random correlation due to the random initialization of the weights. The statistical indicator $R^2$ values in the present study remain above the benchmark value of 0.95 for the best fit and well above 0.8 required to meet the minimum criteria.

ANN was used to construct a response surface for the complete experimental plan considering the variables as disease condition (diabetes mellitus), age and vitamin profiles of the subjects. Three dimensional response surface and contour plots for serum vitamin profiles were shown in Figure(s) 1-11.

![Figure 1: Response Surface plot of vitamin A.](image1)

![Figure 2: Response Surface plot of vitamin D.](image2)

![Figure 3: Response Surface plot of vitamin E.](image3)

![Figure 4: Response Surface plot of vitamin K.](image4)

![Figure 5: Response Surface plot of vitamin C.](image5)
The optimum concentration of vitamin D and K were investigated using the plots and found that the variables are...
moderately influencing the vitamin concentration since the nature of the plot was almost uniform, excluding some areas where the peaks were formed. The vitamin A and E were greatly affected by the disease condition variable as the optimum value was again found with the control subjects.

The plot of vitamin C has affirmed that the disease condition was positively influencing the vitamin concentration until an optimum value was reached. The response surfaces of B3 and B6 reached the optimum level uniformly due to sufficient supplementation however at some areas the response surface is reduced to low levels even under unfavorable conditions. The plots of vitamin B1, B2 and B12 were uniform at several conditions but at the central point of the age of subjects, the vitamin levels were reduced to a greater extent. The predicted levels of vitamin concentration were reached at the most favorable conditions.

The yield values for different concentrations of the variable can also be predicted from the respective response surface plots. The maximum predicted value is indicated by the surface confined in the response surface plot. The best predicted values were depicted in the Table 2.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Vitamin</th>
<th>Vitamin value (ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>1064.5</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>73.22, 45.03</td>
</tr>
<tr>
<td>3</td>
<td>E</td>
<td>1217.6</td>
</tr>
<tr>
<td>4</td>
<td>K</td>
<td>1024</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>7177.9</td>
</tr>
<tr>
<td>6</td>
<td>B1</td>
<td>15.732</td>
</tr>
<tr>
<td>7</td>
<td>B2</td>
<td>13.390</td>
</tr>
<tr>
<td>8</td>
<td>B3</td>
<td>6.619</td>
</tr>
<tr>
<td>9</td>
<td>B4</td>
<td>31.927</td>
</tr>
<tr>
<td>10</td>
<td>B6</td>
<td>1.481</td>
</tr>
<tr>
<td>11</td>
<td>B12</td>
<td>38.786</td>
</tr>
</tbody>
</table>

4. Conclusion

Diabetes mellitus appears to have great effect on the decline of vitamin concentrations in both male and female. Diabetes patients who are having vitamin supplements are slightly lower concentrations of vitamins A, E, C, B1, B2, B6 and B12 were observed when compared to non diabetic control group. By using ANN in the Diabetes mellitus patients showing that the maximum decline effect on the A and E vitamins. That shows a planned dietary intake and supplementation of deficient vitamins (500 – 1000 IU vitamin/day) help to reduce the risk of the diabetes in patients.

References


[17] Mandal, Sumantra, Sivaprasad PV, Venugopal S, Murthy KPN: Artificial neural network modeling to evaluate and predict the deformation behavior of
stainless steel type AISI 304L during hot torsion.


