Original scientific paper
Izvorni znanstveni članak

ISSN 1848-817X
Coden: MEJAD6 52 (2022) 3

Connection between glycemic variability obtained using the uniGluko system and the quality of life people with type 1 diabetes

Povezanost varijabilnosti glikemije dobivene pomoću uniGluko sustava i kvalitete života osoba sa šećernom bolešću tipa 1

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Summary

Research has shown that glycemic variability increases the risk of the development of acute and chronic complications with diabetes. Accordingly, the assessment of glycemic variability is of great importance to determine the quality of life for people suffering from diabetes.

Objective: To examine the connection between glycemic variability and the quality of life for people with type 1 diabetes who use self-monitoring blood glucose devices.

Respondents and methods: 42 respondents participated in the research with an average age of 39.6, who are treated with intensified insulin therapy. For the purpose of glycemic variability assessment, an innovative uniGluko system is used, which enables the display of glycemia in a unique graphic interface in the form of numeric values within the last three months from which a glycemic variability index was calculated as well as a general information survey, a survey on the quality of life from the World Health Organization (WHOQOL – BREF) and a short questionnaire regarding illness perception (Brief – IPQ).

Results: By usage of standard deviation as a glyemic variability measure, statistically significant results have been obtained and they demonstrate that lower glycemic variability is connected to better quality of life (rs=-0.4571; p=0.0023), higher satisfaction with health (rs=-0.3186; p=0.0398) and reduced impact of disease on emotional life (rs=0.4097; p=0.,0071). Lower glucose variability implies reduced impact of disease on everyday life (rs=0.3091; p=0.0464), reduced incidence of symptoms (rs=0.3441; p=0.0255), and patients' sense that they have more control over disease (rs=-0.5185; p=0.0004).

Conclusion: The glycemic variability has a negative impact on life quality and health of patients with diabetes type 1.

Key words: diabetes mellitus, glycemic variability, quality of life

Novelty statement: This scientific paper which has for the first time dealt with the topic of glycemic variability and its impact on the quality of life for patients with type 1 diabetes in the Republic of Croatia. During this research, the innovative uniGluko system has been used for acquisition of data about glycaemia self-monitoring using the self-monitoring glucose devices.

Sažetak

Istraživanja pokazuju da varijabilnost glikemije povećava rizik za razvitak akutnih i kroničnih komplikacija šećerne bolesti. Shodno tome, procjena varijabilnosti glikemije od velikog je značaja za utvrđivanje kvalitete života oboljelih osoba.

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Received/*Primljeno* 2021-01-17; Revised/*Ispravljeno* 2022-05-19; Accepted/*Prihvaćeno* 2022-06-01

Cilj: Ispitati povezanost varijabilnosti glikemije i kvalitete života osoba sa šećernom bolešću tipa 1 koji mjere glukozu u krvi samomjeračima.

Ispitanici i metode: U istraživanju je sudjelovalo 42 ispitanika prosječne starosti od 39,6 godina koji se liječe intenziviranom inzulinskom terapijom. U svrhu procjene varijabilnosti glikemije korišten je inovativni uniGluko sustav koji omogućuje prikaz glikemije u jedinstvenom grafičkom sučelju i u obliku numeričkih vrijednosti u posljednja tri mjeseca iz kojih se vršio izračun indeksa varijabilnosti glikemije. Korišten je upitnik općih podataka, upitnik kvalitete života Svjetske zdravstvene organizacije (WHOQOL- BREF) i Kratki upitnik percepcije bolesti (Brief- IPQ).

Rezultati: Uporabom standardne devijacije kao mjere varijabilnosti glikemije dobiveni su statistički značajni rezultati koji pokazuju da je niža varijabilnost glikemije povezana s osjećajem bolje kvalitete života (rs=-0,4571; p=0,0023) i većim zadovoljstvom svojim zdravljem (rs=-0,3186; p=0,0398) te osjećajem manjeg utjecaja bolesti na emocionalni život (rs=0,4097; p=0,0071). Sa smanjenjem varijabilnosti glikemije smanjuje se utjecaj bolesti na svakodnevni život (rs=0,3091; p=0,0464) i učestalost simptoma šećerne bolesti (rs=0,3441; p=0,0255) te je veći osjećaj kontrole nad bolešću (rs=-0,5185; p=0,0004).

Zaključak: Varijabilnost glikemije ima nepovoljan učinak na kvalitetu života i zdravlja osoba oboljelih od šećerne bolesti tipa 1.

Ključne riječi: šećerna bolest, varijabilnost glikemije, kvaliteta života

Doprinos provedenog istraživanja: Znanstveni rad koji je po prvi put obradio temu varijabilnosti glikemije i utjecaja na kvalitetu života bolesnika sa šećernom bolešću tipa 1 u Republici Hrvatskoj. U sklopu istraživanja korišten je inovativni uniGluko sustav za prikupljanje rezultata samokontrole glikemije mjerene samomjeračima glukoze.

Med Jad 2022;52(3):179-188

Introduction

Glycemic variability is the main indicator of tendency towards hyperglycemia and hypoglycemia, and it increases the risk of complications connected to diabetes.[1] People with diabetes are coping with the challenge of maintaining glycaemia within target values, that is, decreasing glycemic variability.[2] Most people suffering from diabetes are interested in which ways they may successfully increase care and improve self-control of the disease. Numerous parameters assess the regularity of diabetes; however, they do not offer any insight into the daily movements of glycemia during a specific time.

Glycosylated hemoglobin (HbA1c) is an important parameter to get an insight of diabetes regulation within the previous three months.[3] Maintenance of HbA1c within the target values prevents the development and progression of chronic complications of diabetes.[4] The test results show the average concentration of plasma glucose, but they do not show variability. This means that two persons, one with stable concentration of plasma glucose and one with extremely high or low glycemic values, can have the same HbA1c values. HbA1c is not the only criteria to evaluate the diabetes regulation. Self-monitoring of glucose levels on everyday basis is a key component in diabetes regulation[5], and it is done in order to adjust the dosage of insulin therapy, to reduce the risk of hypoglycemic episodes and to reach the HbA1c target value.[4] The usual method of capillary blood glucose self-testing consists of pricking the fingertip with the needle in order to sample the blood drops, and of applying the drops to the testing strip inserted into the self-monitoring glucose device, which shows the plasma glucose value in just a few seconds.[6]

For a better insight into the regulation of diabetes, people with diabetes need to keep a diary of self-control, in which it is necessary to precisely take note of the data regarding measured values of plasma glucose levels, the date and time of measurement as well as the amount of medication the person takes. It is well-known that part it does not succeed in precisely keeping a diary of self-control[7] satisfactorily, so the information which these diaries of self-control provide is not fully accurate, thus this does not fully help regarding control nor self-control of diabetes.

With the advancements in technology in the last twenty years, there have been more possibilities to self-monitor glucose by using a sensor for continuous glucose monitoring (CGM). Continuous monitoring provides the most reliable and the most detailed insight of glycemic variation[8], and represents the gold standard.[9] The glucose level can be continuously read on a specific receiver, smartphone or smartwatch (rt CGM), or intermittently by scanning (isCGM), if the patient requests so.[4] Besides the absence of discomfort and pain, CGM also enables an insight into daily glucose levels in the organism and the dynamic of its changes.[5] The recorded daily values during a longer period give an insight into glycemic parameters of diabetes regulation.

In the Republic of Croatia, Regulation Amending and Supplementing Regulation on Orthopaedic and Other Aids entered into force on 16 August 2018, by which new aids have been included in the list of aids of the Croatian Health Insurance Fund: a device for scanning the glucose level in interstitial fluid with the additional option of measuring glucose and ketones in blood, of protected name 'FreeStyle Libre Flash Glucose Monitoring System - Reader', sensor for measuring glucose in interstitial fluid (FreeStyle Libre Flash Glucose Monitoring System - Sensor), of the manufacturer Abbott Diabetes Care Limited, and transmitter and sensor for continuous glucose measuring. Right to aid 'Libre', by printed approval on aids of Fund, exercise children from age 4 to 18, pregnant women, blind people, patients with diabetes type 1 and patients on intensive insulin therapy (four or more doses of insulin or insulin pump), with proved hypoglycaemia in hospital conditions. Before the entry into force of this Regulation, the uniGluko system was used to get an insight into glycemia movements and to establish glycemic variability.[10]

Therefore, this study examines the glucovariability of patients who use self-monitoring blood glucose devices.

Despite the development and the benefits of technology, the so-called "human factor" also has a significant impact in diabetes regulation. This is supported by the results of the survey which was conducted across 1503 type 1 diabetics. The results have shown that, according to the patients, there are some obstacles with accepting the new technologies, that is, the "annoyance" for having to carry the device (40 %), and the fact that the device has to be attached to the body (35 %). The younger examinees and those with a shorter duration of illness have expressed more attitudes that are negative about the new technologies.[11]

The Faculty of Electrical Engineering and Computing (FER) and Vuk Vrhovac University Clinic have started a pilot project System for the control and management of diabetes on a national level, uniGluko™. The aim of the project was to enable a simple and reliable method for data entry regarding the measured values of glucose in the blood through reading the glucometer memory into a unique system, available to all doctors and their offices. All that is necessary is one device in which it is possible to read the memory from any glucometer which has been approved for use in the Republic of Croatia as well as numerically and graphically present glycemic movement within the last three months.[12]

The aim of this survey is to examine the connection of glycemic variability and life quality of type 1 diabetics who are given the intensive insulin therapy, and who use self-monitoring blood glucose devices.

Respondents and methods

Respondents

The survey includes persons over the age of 18 who suffer from type 1 diabetes for at least a year, who are given the intensive insulin injection therapy, and who have cognitive and psychomotor abilities necessary to complete a questionnaire. They were sampled from the general population of patients treated in the Department of Endocrinology and Metabolic Diseases, Osijek Clinical Hospital, using random selection, who met inclusion and exclusion criteria, during the 3-month medical examinations, from September to November 2017. There were 47 examinees. According to the included criteria, 42 examinees participated in the research. The respondents were notified of the research aim and confirmed their written consent of participation in the research with their signatures.

The research was carried out in accordance with ethical principles and human rights.

Written consent was also obtained from the Ethics Committee in J.J. Strossmayer University in Osijek, Medical Faculty Osijek (class: 602-04/17-08/12, number: 2158-61-07-17-169), the Committee for ethical and class issues for healthcare medical nurses-technicians, Osijek Clinical Hospital (number: R1-11681-6/2017). The research was carried out in accordance with the ethical principles of the Helsinki Declaration.

Methods

The following instruments were used in the conducted research:

- **uniGluko system** – in order to collect information regarding plasma glucose values obtained through self-control, the uniGluko system was used, which enables memory reading of all self-monitoring blood glucose devices which satisfy the prescribed ISO standards for the Republic of Croatia as well as present glycemia in a unique graphic interface in the form of numeric values. Glycemia is graphically presented and numerically read by data collected in the last three months, regarding the number of measurements, average measurement value (mmol/L), minimal measurement values (mmol/L), maximum measurement values (mmol/L), the average number of daily measurements, number of days

without measurement, standard deviation (mmol/L). The graphic presentation gives information regarding glycemia which is below target values, above target and within target values, expressed in percentages. The main features of the innovative uniGluko system are readings of all leading self-monitoring blood glucose devices whose memory data is extracted automatically and transferred safely through the internet in a certified application, CHIS (Central Health Information System) with preserved data integrity.[12] 34 660 individual measurements were statistically processed in the last 3 months among 42 respondents, from which a glycemic variability index was calculated.

In the Republic of Croatia, insured diabetics have the right to a set for quick blood sugar monitoring (self-monitoring blood glucose device, lancing device, test strips, lancets)[13] with the right to choose the manufacturer. For that reason, various self-monitoring blood glucose devices that have been licenced and approved for usage in the Republic of Croatia were observed during this research.

The uniGluko device did not read data from self-monitoring devices with invalid date and time, but rather only from those with correct settings.

- **A short questionnaire on illness perception - Brief- IPQ** (The Brief Illness Perception Questionnaire), intended for the evaluation of illness perception, was developed in 2006, and the authors are Broadbent, Petrie, Main, and Weinman. It consists of nine questions. Each answer apart from the last (open type) is evaluated on a linear scale, the Thurstone scale, with 0-10 defined endpoints (0 = the most positive), 10 = the most negative). The first five questions examine the cognitive perception of illness (influence, duration, personal illness control, therapy control, symptoms). The sixth question (concern) and the eighth (emotions) examine the emotional perception of the illness. The seventh question (understanding) examines the understanding of the illness. The ninth question (causes) examines the causes of the illness which the respondent considers having caused the illness. Each question represents one dimension of the illness experience. The result of each dimension is the answer the respondent circled.[15]

- **The questionnaire regarding the quality of life by the World Health Organization - WHOQOL-BREF** (World Health Organization Quality of Life-Brief), the shortened version of the questionnaire is WHOQOL- 100. It is intended for the examination of the quality of life. It consists of 26 questions. The answers to each question are given on the Likert scale from 1-5. The results are obtained through a combination of answers to 24 questions which are classified into four domains: physical health, psychological health, social relationships, and environment. The result within each domain is expressed as an average answer.[14]

- **General information questionnaire:** contains gender information, age as well as information regarding the year of diabetes diagnosis, current therapy, accompanying therapy, the appearance of chronic complications, the presence of risk factors, hypoglycemia as well as information regarding physical mass, height, body mass index (BMI) and blood pressure.

Statistical methods

All gathered categorical data is represented by absolute and relative frequencies, while numerical data is described as the arithmetic mean and standard deviation (SD) and median as well as interquartile range. the Chi-square test is used For the comparison of categorical data among independent groups, and, when necessary, the Fisher exact test, while the Spearman correlation test is used for testing correlations between numerical and measured values and grade on the Likert scale.[16]

In this survey, the glycemic variability is evaluated according to data from glycaemia self-monitoring devices, by calculating standard deviations (SD).

Statistical analysis was done using MedCalc program software (version 14.12.0, MedCalc Software bvba) and R (version 4.1.2.), with the selected level of statistical significance α=0.05, while all the P values were on both sides.

Results

Forty-two respondents participated in the research with an average age of 39.6 ± 14.3 years (arithmetic mean ± standard deviation) ranging from 20 to 63 years of age. According to gender, there were 18 (42.9%) male respondents and 24 (57.1%) female respondents. All respondents in the sample had type 1 diabetes. Current therapy includes insulin for all respondents. Among chronic complications, microvascular complications dominate with the highest percentage of respondents, 14 (33.3%) had ocular complications. The arithmetic mean HbA1c-a for all respondents amounted to 7.7%, that is the median HbA1c-a totaled 7.6%. Hypoglycemic episodes were present in 41 respondents (97.6%), of which 27 (65.9%) had symptomatic episodes, three (7.3%) had asymptomatic episodes, while 11 (26.8%) respondents had both symptomatic and asymptomatic episodes.

The average plasma glucose value, as well as standard deviation as glycemic variability measure, has been compared with the statements on life quality and satisfaction with health, and statistically significant correlation has been established: lower plasma glucose implies more satisfaction with life quality (r_s=-0.3209; p=0.0383), and health (r_s=-0.3318; p=0.0318). Lower plasma glucose variability implies more satisfaction with life quality (r_s=-0.4571; p=0.0023), and health (r_s=-0.3186; p=0.0398). *Table 1* shows a statistically significant positive correlation for medical treatment necessity, while the sense of security and total intensity of experiencing have been determined for a negative statistically significant correlation.

In addition, average plasma glucose value has been compared with variables that measure the intensity of experiencing certain things. The results show that only one out of eight statements showed a statistically significant correlation: medical treatment necessity. Higher value of glucose in blood implies more necessity for medical treatment (r_s=0.4097; p=0.0071). The average plasma glucose value (*Table 2*), as well as standard deviation as glycemic variability measure (*Table 3*), has been compared with the statements on the examinees' capability to perform certain actions. All correlations are of negative value, which demonstrates that the capability to perform certain activities reduces with the increase of average plasma glucose and by increase of plasma glucose variability, and vice versa.

Table 4 shows only one statistically significant negative correlation concerning satisfaction upon performing everyday activities. Lower plasma glucose variability implies more satisfaction upon performing everyday activities.

The average plasma glucose value was compared to questions relating to examinees' satisfaction. No statistically significant correlations have been determined, which shows that there is no connection between plasma glucose and satisfaction.

The average plasma glucose value, as well as standard deviation, was compared to questions relating to the perception of the disease. The results have shown that an increase of the average plasma glucose value (*Table 5*) and an increase of the glycemic variability (*Table 6*) implies more impact of diabetes on everyday life, as well as a higher incidence of disease symptoms and an impact of the disease on emotional life. In addition, higher glucose value implies less control over the disease.

Table 1 Testing the significance of the relationship between the standard deviation of plasma glucose and the intensity of experiencing certain things

Tablica 1. Testiranje značajnosti veze između standardne devijacije glukoze u plazmi i intenziteta doživljaja određenih stvari

Statement (T10 to T16) & Standard deviation of glucose *Izjava (T10 do T16) & Standardna devijacija glukoze*	Spearman R	p- value
Prevention of carrying out duties due to pain (T10) *Sprječavanje izvršavanja obaveza zbog bolova (T10)*	0.2027	0.1979
Necessity of medical treatment (T11) *Nužnost medicinskog tretmana (T11)*	**0.4657**	**0.0019**
Enjoying life (T12) *Uživanje u životu (T12)*	-0.1228	0.4384
Feeling that your life has meaning (T13) *Osjećaj da Vaš život ima smisla (T13)*	-0.1424	0.3683
Ability to concentrate (T14) *Sposobnost koncentracije (T14)*	-0.2463	0.1158
Feeling of security (T15) *Osjećaj sigurnosti (T15)*	**-0.3244**	**0.0361**
How healthy is your environment (T16) *Koliko je zdrav okoliš (T16)*	-0.0258	0.8711
Total intensity* *Intenzitet ukupno**	**-0.4179**	**0.0059**

*The total of all scores for statements T10 to T16

**zbroj svih ocjena za izjave T10 do T16*

Table 2 Testing the significance of the relationship between the average value of plasma glucose and the ability of the respondent to do certain things
Tablica 2. Testiranje značajnosti veze između prosječne vrijednosti glukoze u plazmi i sposobnosti ispitanika za obavljanje određenih stvari

Statement (T17 to T22) & Average value of glucose *Izjava (T17 do T22) & Prosječna vrijednost glukoze*	Spearman R	p- value
Sufficient amount of energy for daily life (T17) *Dovoljna količina energije za svakidašnji život (T17)*	**-0.376**	**0.0141**
Acceptance of physical appearance (T18) *Prihvaćanje tjelesnog izgleda (T18)*	-0.2093	0.1834
Sufficient amount of money for satisfying needs (T19) *Dovoljna količina novca za zadovoljavanje potreba (T19)*	-0.1292	0.4148
Availability of information necessary for daily life (T20) *Dostupnost informacija potrebnih za svakodnevni život (T20)*	-0.1767	0.2628
Opportunities for recreation (T21) *Prilike za rekreaciju (T21)*	**-0.2679**	**0.0863**
Ability to move (T22) *Sposobnost kretanja (T22)*	-0.2162	0.169
Total ability* *Sposobnost ukupno**	**-0.4156**	**0.0062**

*The total of all scores for statements T17 to T22
**zbroj svih ocjena za izjave T17 do T22*

Table 3 Testing the significance of the relationship between the standard deviation of plasma glucose and the ability of the respondent to do certain thing
Tablica 3. Testiranje značajnosti veze između standardne devijacije vrijednosti glukoze u plazmi i sposobnosti ispitanika za obavljanje određenih stvari

Statement (T17 to T22) & Standard deviation of glucose *Izjava (T17 do T22) & Standardna devijacija glukoze*	Spearman R	p- value
Sufficient amount of energy for daily life (T17) *Dovoljna količina energije za svakidašnji život (T17)*	**-0.292**	**0.0606**
Acceptance of physical appearance (T18) *Prihvaćanje tjelesnog izgleda (T18)*	-0.1656	0.2947
Sufficient amount of money for satisfying needs (T19) *Dovoljna količina novca za zadovoljavanje potreba (T19)*	-0.1967	0.2118
Availability of information necessary for daily life (T20) *Dostupnost informacija potrebnih za svakodnevni život (T20)*	**-0.3221**	**0.0375**
Opportunities for recreation (T21) *Prilike za rekreaciju (T21)*	**-0.4295**	**0.0045**
Ability to move (T22) *Sposobnost kretanja (T22)*	-0.2346	0.1349
Total ability* *Sposobnost ukupno**	**-0.4921**	**0.009**

*The total of all scores for statements T17 to T22
**zbroj svih ocjena za izjave T17 do T22*

Table 4 Testing the significance of the relationship between the standard deviation of plasma glucose and the satisfaction of the respondent
Tablica 4. Testiranje značajnosti veze između standardne vrijednosti glukoze u plazmi i zadovoljstva ispitanika

Statement (T23 to T31) & Average value of glucose *Izjava (T23 do T31) & Prosječna vrijednost glukoze*	Spearman R	p- value
Sleep satisfaction (T23) *Zadovoljstvo spavanjem (T23)*	-0.2261	0.15
Satisfaction with the ability to perform daily activities (T24) *Zadovoljstvo sposobnostima obavljanja svakodnevnih aktivnosti (T24)*	**-0.3668**	**0.0169**
Satisfaction with personal relationships (T25) *Zadovoljstvo osobnim odnosima (T25)*	-0.1411	0.3727
Self-satisfaction (T26) *Zadovoljstvo samim sobom (T26)*	-0.1518	0.3373
Satisfaction with personal qualities (T27) *Zadovoljstvo osobnim kvalitetama (T27)*	-0.1719	0.2763
Satisfaction with sex life (T28) *Zadovoljstvo seksualnim životom (T28)*	0.0659	0.6781
Satisfaction with the support of friends (T29) *Zadovoljstvo podrškom prijatelja (T29)*	-0.0207	0.8963
Satisfaction with living space conditions (T30) *Zadovoljstvo uvjetima stambenog prostora (T30)*	0.1138	0.4728
Satisfaction with the availability of medical services (T31) *Zadovoljstvo dostupnošću medicinskih usluga (T31)*	-0.0219	0.8904
Total satisfaction* *Zadovoljstvo ukupno**	-0.1424	0.3683

* The total of all scores for statements T23 to T31
** zbroj svih ocjena za izjave T23 do T31*

Table 5 Testing the significance of the relationship between average plasma glucose and illness perception
Tablica 5. Testiranje značajnosti veze između prosječne glukoze u plazmi i percepcije bolesti

Statement (T1 to T7) & Average glucose value *Izjava (T1 do T7) & Prosječna vrijednost glukoze*	Spearman R	p- value
Influence of diabetes on daily life (T1) *Utjecaj DM na svakodnevni život (T1)*	**0.4223**	**0.0054**
Control over diabetes (T2) *Kontrola nad šećernom bolešću (T2)*	**-0.4539**	**0.0025**
How much treatment assists against illness (T3) *Koliko Vam liječenje pomaže u bolesti (T3)*	-0.1024	0.5189
Frequency of diabetic symptoms (T4) *Učestalost simptoma šećerne bolesti (T4)*	**0.3591**	**0.0195**
Concern over diabetes (T5) *Zabrinutost zbog šećerne bolesti (T5)*	0.213	0.1755
Knowledge about diabetes (T6) *Poznavanje šećerne bolesti (T6)*	0.066	0.678
Influence of diabetes on emotional life (T7) *Utjecaj DM na emocionalni život (T7)*	**0.3287**	**0.0336**

Table 6 Testing the significance of the relationship between the standard deviation of plasma glucose values and illness perception
Tablica 6. Testiranje značajnosti veze između standardne devijacije vrijednosti glukoze u plazmi i percepcije bolesti

Statement (T1 to T7) & Standard deviation of glucose *Izjava (T1 do T7) & standardna devijacija glukoze*	Spearman R	p- value
Influence of diabetes on daily life (T1) *Utjecaj DM na svakodnevni život (T1)*	**0.3091**	**0.0464**
Control about diabetes (T2) *Kontrola nad šećernom bolešću (T2)*	**-0.5185**	**0.0004**
How much treatment assists against illness (T3) *Koliko Vam liječenje pomaže u bolesti (T3)*	-0.1352	0.3934
Frequency of diabetic symptoms (T4) *Učestalost simptoma šećerne bolesti (T4)*	**0.3441**	**0.0255**
Concern over diabetes (T5) *Zabrinutost zbog šećerne bolesti (T5)*	0.1017	0.5216
Knowledge about diabetes (T6) *Poznavanje šećerne bolesti (T6)*	0.1225	0.4395
Influence of diabetes on emotional life (T7) *Utjecaj DM na emocionalni život (T7)*	**0.4097**	**0.0071**

Discussion

People with diabetes cope with many difficulties daily, trying to coordinate illness control and the daily obligations in life. Patients must deal with their illness all day long and make numerous decisions to maintain the stability of their illness. Medication for the treatment of diabetes, such as insulin, can significantly positively affect their quality of life by decreasing the levels of plasma glucose, but also negatively have an effect by discomfort caused by the usage of injectable therapy, the complexity of the regime due to frequent and multiple daily doses as well as the possibility of hypoglycemic episodes appearing, that is, inappropriately low plasma glucose values or significant plasma glucose variations. The International Diabetes Federation (IDF) estimates that half of people with diabetes do not take adequate therapy, or the patients do not adhere to the prescribed therapy, that is, that therapy does not achieve desired results. 12% of the world's health expenses (673 billion dollars) go towards treating diabetes.[17] The number of diabetics has increased from 108 million (year 1980) to 422 million (year 2014). The increase is more rapid in low-income and middle-income countries. In 2019, diabetes was a ninth death cause in the world with an average of 1.5 million deaths.[18] As part of 2030 Agenda for Sustainable Development, the UN member states have set the following objectives: reduction of premature mortality from non-communicable diseases (NCD) - including diabetes - by a third, safe access to essential medications at affordable prices, comprehensive health care.[19] Life with diabetes is often difficult and commonly affects the patient's behavior, self-confidence, and satisfaction. In addition, there is continuous pressure on the necessity of achieving optimal long-term glycemic control, with the goal of decreasing the risk of developing long-term complications and improving the quality of life.[20] The World Health Organization offers the foundations for the implementation of the concept of quality of life connected to health, whereat the quality of life reflects the subjective perception of health. The increased frequency of chronic health conditions, which require long-term treatments and care, is the main cause for the development of the mentioned concept.[21]

In this research, the majority of patients were younger or middle-aged (39.6 ± 14.3 years). All respondents in the sample have type 1 diabetes and they were treated with insulin therapy in an intensified form, that is, four or five daily insulin applications. The average duration of diabetes amounted to 14.1 ± 11.2 years; thus, it was about patients with a longer duration of diabetes.

A smaller number of respondents had a confirmed development of chronic complications in this research, the most common complications were those of microvascular etiologies, diabetic polyneuropathy, and retinopathy. This result is satisfactory because it shows that most of our respondents are not coping with the development of chronic complications, which means that adhering to the general measure of

treatment, adequate pharmacological therapy, and regular self-control can prevent difficulties and raise the quality of life. Some studies have established that an increase in the duration of diabetes is connected to a decrease in the quality of life among the Finnish population regardless of the type of diabetes.[22]

Concerning glycemic control the average value HbA1c-a amounted to 7.7 ± 1.3%, with a total range of a minimal 5.0% to a maximum of 12.7%, hence with the majority of respondents glycemic control was not fully satisfactory. Regular tracking of glycemic control and adjustment of therapy according to the appropriate goal values HbA1c is a key demand of all modern diabetic guidelines as well as an indicator of high-quality healthcare in numerous national healthcare systems. Standardized, available, and high-quality analytical methodology, along with good knowledge of biological factors that can affect test findings, are crucial for the safe clinical application of HbA1c.[23]

The majority of research shows that better glycemic control is connected with better quality of life, especially if the quality of life is evaluated with specific measures which include the patient's perception of symptoms until the lower levels of glycemia are not connected to a significant increase in stress in the patient. It seems that the benefits of good glycemic control have a bad side, research shows that they are, at least for most patients, a great burden.[24]

The respondents in this research had relatively frequent hypoglycemic episodes, whether symptomatic or asymptomatic. The most common ones appeared as hypoglycemia throughout the day, both categories with a frequency of less than one time per week. The respondents assessed the quality of their life with a 4, health satisfaction with a 3 (graded as 1 – very bad to 5 – very good). In comparison with people without diabetes, the majority of the study reported a lower quality of life for people with diabetes, especially regarding physical functioning. However, people with diabetes indicate a higher quality of life than others who have many other chronic conditions (such as heart problems, epilepsy, arthritis, multiple sclerosis, strokes, and lung problems) in everyday functioning.[24]

Research in the UK has shown that respondents with diabetes have a moderate or low quality of life. Factors that additionally contribute to a lower quality of life include lower level of education, lower income, older age, female gender, number of complications, number of comorbidities, and lower level of physical activity. Multiple analyses have shown that the level of physical activity is the only significant behavior that can encourage a better quality of life after control of demographic and medical variables.[25]

Glycemic variability

This examination has shown that glycemic variability is also one of the crucial factors that have an impact on different aspects of patient life quality.

In this examination, statistically significant results have been obtained and they demonstrate that lower glycemic variability is connected to better quality of life, higher satisfaction with health, and reduced impact of disease on emotional life. Lower glucose variability implies reduced impact of disease on everyday life, reduced incidence of symptoms, and patients' sense that they have more control over the disease.

Glucose control, glycemic variability, and risk for hypoglycemia are intimately related, and it is now evident that glycemic variability is important in both the physiology and pathophysiology of diabetes.[26] The survey from 2015 has shown significant connection of glycemic variability and life quality/satisfaction of type 1 diabetics.[27] It appears that the glycemic variability will become a parameter to optimally monitor glycaemia above the standard glycemic parameters, such as blood glucose and HbA1c.[28]

The reduction of glycemic variability, and thus the life quality improvement of diabetics, can be achieved by applying certain interventions, including adequate education for people with diabetes and their families, introducing advisory programs intended for the relief of ability development to cope with this illness. In order for patients to have more access to health care, Sweden has introduced (besides the doctor appointments) the appointments with diabetes educator nurses.[29] The aim is also to improve patient quality as an extremely important and positive attitude in society towards this illness and support that society as a whole gives to these patients.

Conclusions

All of the examinees are long-lasting type 1 diabetics, and all of them are getting the intensive insulin injection therapy. Most of them did not control and regulate glycaemia in a satisfactory way, since the hypoglycemic episodes occurred relatively often. Glycemic variability expressed by standard deviation, has shown a significant connection with several components for the evaluation of the variability impact on the perception of illness, health and life quality.

Since the results of this survey have shown the negative impact of glycemic variability on life quality and health of patients with diabetes type 1, it is important to encourage diabetics to educate themselves, to accept new technologies, and to self-monitor. In future surveys, it is necessary to include more examinees and to conduct a questionnaire specific for diabetes.

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