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New ways of diabetes management with smart data and genomic data

Abstract: By 2025, the number of diabetic patients worldwide could rise by more than 50 percent from now 250 million to about 380 million. With about 6 million patients, diabetes mellitus is one of the greatest national diseases in Germany.

Type 1 diabetes is a mostly genetically induced autoimmune disease, type 2 diabetes is a civilization disease and arises due to lack of exercise and poor diet. Regardless of the type of diabetes, it is important for those affected to manage their own insulin production of the body and to harmonize these with appropriate possibilities. Because of the harmful side effects of exogenous insulin doses, the major focus should be on a sustainable behavioral change and low-threshold nutritional coaching.

The most important side effects of diabetes are damage to the vascular system with possible consequences: myocardial infarction, stroke, kidney weakness, nasal damage and erectile dysfunction. A concept for a knowledge-based expert system for the therapy of diabetes mellitus is presented, in which genetic, anatomical and physiological parameters are recorded, evaluated and visualized by means of a model-based approach to specific therapeutic recommendations. The "user interface" is a digital avatar, which can display the model parameters in various "abstraction levels" as a metamodel.

Keywords: Diabetes Mellitus, Genomic Data, Genomic Modelling, Health Avatar, Virtual Reality, Augmented Reality, Expert System, Knowledge Base, Explanation Component

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1 Introduction

Diabetes mellitus is one of the largest national diseases in Germany, with approximately six million patients and presumably as many people with unrecognized diabetes or risk of this metabolic disease. The United Nations estimates that by 2025 the number of diabetic patients worldwide will rise by more than 50 percent from now 250 million to about 380 million. Diabetes was therefore the first disease not triggered by an infection by the United Nations to be a global threat to mankind [1]. In Germany in 2014, a total of 213,000 people were treated in the hospital as a full-station patient due to diabetes mellitus. While type 1 diabetes is an autoimmune disease, in which the affected person can produce little or no insulin, the main causes of type 2 diabetes are the wrong habits of diet and exercise. The majority of patients suffered from type 2 diabetes (79%) [2].

Type 1 diabetes is often already occurring in childhood and adolescence. Approximately 300,000 people in Germany are estimated to have type 1 diabetes. Reliable figures do not exist, since diabetes is not a reportable disease in Germany. Type 1 diabetes occurs when the body's immune system, which primarily serves the defense of pathogenic germs, is directed against the insulin-producing cells of the pancreas and destroys them.

Type 2 diabetes is caused by an increase in insulin resistance which is no longer adequately compensated by an increase in the insulin synthesis of the body and a progressive malfunction of the insulin-producing beta cells. Research has recently identified another important mechanism: chronic, subconscious - that is clinically inconspicuous - inflammatory processes occurring throughout the body. These inflammatory processes increase insulin resistance, increase the risk of developing and progressing diabetes, and are also closely linked to an increase in cardiovascular risk. Slightly elevated levels of inflammatory markers in the blood - often the highly sensitive C-reactive protein (hsCRP) are measured - indicate such inflammatory processes [3]

2 Causes and consequences of diabetes

Regardless of the type of diabetes, it is important for those affected to record their own insulin production of the body and to harmonize these with appropriate possibilities.

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Because of the harmful side effects of exogenous insulin doses, the major focus should be on a sustainable change of behaviour and low-threshold nutritional coaching. The most important side effects are damage to the vascular system with possible consequences: myocardial infarction, stroke, kidney weakness, nasal damage and erectile dysfunction. They are often referred to as "late damages". However, this term is misleading because many diabetes sequelae can already occur at a very early stage of diabetes - often even when a prediabetes (a diabetes pre-stage) exists.

In addition, there are new findings on the genomic mechanisms of diabetes. Genes have been detected that have an influence on the blood levels of the protective IL-1RA. A study has shown that a genetic increase in the IL-1RA inhibitor can provide protection against diabetes [4]. Other genes associated with diabetes as well as the inducing factors of little movement and wrong diet [5]:

- ACTN3: The ACTN3 protein is a component of fast muscle fibers. Its occurrence can lead to short-term peak performances with powerful muscular performance such as power sports. A variant in ACTN3 gene leads to the absence of this protein. This leads to persistent muscular performance, which has an advantageous effect on endurance sports.
- ADRB1 (beta-1-adrenergic receptor): ADRB1 fulfills signal transduction tasks Regulation of the heart function and the circulation, as well as in the cleavage of fats. The efficacy of beta blockers may be altered with ADRB1 variants.
- ADRB3 (beta-3 (ß3) -adrenergic receptor gene): ADRB3 gene variants can affect the activity of the β3-adrenergic receptor formed. Reduced activity of the receptor reduces the degradation of lipids (lipolysis) of the body tissue, which in turn can increase the likelihood of weight gain.
- HFE - hemochromatosis gene. The HFE gene encodes the protein of the same name. It plays an important role in the regulation of the iron budget. In untreated haemochromatosis, approximately 20-50% of those affected have symptoms of diabetes before tissue changes of the liver occur. 70% of those affected with liver lesions, such as liver cirrhosis, have diabetes.

For the treatment of diabetes, lifestyle changes and, if necessary, the further administration of insulin may be necessary. In relation to the cross-sectional effect of medication in type 2 diabetes, The following genes of relevance:

- CYP2C9 gene (encodes the protein cytochrome P450-2C9). Enzymes for the metabolism of body-borne substances. They convert substances such as drugs into a water-soluble form. Also for oral antidiabetics (type II) such as glibenclamide, glipizide, glimepiride, rosiglitazone, tolbutamide. In the case of "slow metabolisers" the substances can accumulate in the blood and lead to undesired drug effects.
- SLCO1B1 variants may cause differences in the rate of transport of medications and affect the effect of these drugs: nateglinide, repaglinide. A too slow intake of drugs into the liver cells can lead to an increase in the active substance concentration in the blood and thereby to undesirable drug effects. This applies, inter alia, to statins. Statins are used to lower cholesterol levels. If the active substance intake into the liver cells is too slow, statins accumulate in the blood, which can lead to diseases of the muscle tissue (myopathies). These manifest themselves in muscle pain (myalgia) up to the life-threatening dissolution of the cross-striated muscle (rhabdomyolysis).

This is by no means complete, showing the importance of considering the specific genomic phenotype of the patient in the treatment of diabetes.

3 Diabetes management

A concept for a knowledge-based expert system for the patient centered management of diabetes mellitus is presented, in which genetic, anatomical and physiological parameters are recorded and compacted by means of a model-based approach to specific therapeutic recommendations. The "user interface" is a digital avatar, which can display the model parameters in various "compaction levels" as a metamodel.

After the efficacy of model-based expert systems for the diagnosis of diabetes mellitus [6] and therapy recommendations, diet plan [7], the successful extension of knowledge-based therapy support to genetic parameters is also very likely become.

The simulation model to be developed is a spatial and temporal prognosis of the course of the therapy by visualizing the modeled effects on the movement behavior, the nutrition and the medication intake in an intelligible form. It is also possible to generate counseling on different treatment scenarios and, if necessary, to simulate different scenarios on the health vademy by means of virtual reality (VR) and "augmented reality" (AR) elements in order to generate further insights into the eating and movement behavior.

The individual factors of a prevalence of diabetes, which are recognized in the simulation model, which are particularly relevant for prevention, or the behavioral critical factors of a developed therapy in the case of diabetes already demonstrated, are loaded into a personal health check-up to a programmable smart device (i.e. smartwatch). There, the daily behavioral patterns of the patient are constantly checked for congruence with the corresponding behavior-oriented parts of the prophylaxis / therapy recommendations. Additional vital data (such as the pulse) are evaluated in order to be able to alert and alert you to potential crisis situations (especially hypoglycemia).

The AR and AR technologies are increasingly being used in health technology [8]: "AR solutions are designed and developed as mobile applications and made available on mobile devices. With the low-cost availability of mobile devices, the AR solutions will evolve and the markets expand and diversify. "Today, AR technology provides ubiquitous, collaborative, and situational learning. It creates a sense of presence, immediacy, and immersion, which can be beneficial for learning [9].

Nifakos et al. describes the design process of an AR prototype as a training unit for medical professionals to train the right use of antibiotics. The study is based on a standardized evaluation method for teaching. The first results are promising [10].

A wider approach in the field of medical education Kamphuis et al. [9] "Learning in the medical field is to a large extent practical learning and mastery of complex abilities at work in the professional environment. [...]. Modern computer-aided education and, in particular, AR technology has the potential to provide a very realistic learning experience for complex medical conditions. "Jamali describes stationary and mobile AR applications and examines their applicability and efficacy for use in adult education [11] Jamali et al. Have concluded that the useful use of AR on mobile devices supports the user in learning and helps them to better understand complex issues [11].

In the design and implementation of AR-based content, it is important that an interdisciplinary team of specialists cooperate constructively. Computer scientists must work together with pedagogues and, if necessary, psychologists to develop didactic concepts and the appropriate AR interfaces.

Through the use of the health avatar the patient receives the data integrity about his personal data, his illness and his physical potential. The use and use of medications can be simulated in advance and the effect of the substances used can be examined much more closely.

In the patient, behavioral change is induced in an understandable and meaningful manner. It also makes sense to integrate more "gaming elements" with superior reward systems. In the expert mode, the basic parameters of the underlying models can be viewed and tracked.

The proposed approach requires a model-based knowledge base based on different modeling methods and levels. The submodels are integrated into a metamodel, the personalized health assessment, which can also be referenced back into the submodels.

The following basic conditions and research questions have to be investigated:

– The presentation of the metadata of the avatar on mobile devices and as an AR or VR coaching application is planned and the visualization of the explanatory component as a personalized multi-dimensional avatar including 3D representation of the body appears technically possible, e.g. Based on body scanning for 3-D printing or the visualization of actors in computer games.
– Data protection and data security aspects in these personal and sensitive areas require a sensitive education of the subjects and the later users as well as the use of a comprehensive security infrastructure.
– Ethical questions regarding the preparation and the provision of information on critical molecular genetic findings require a particularly sensitive treatment.

4 Conclusion

The social relevance of the project consists in the fact that in many diabetics, a type-appropriate, lasting and lasting behavioral change regarding diet and exercise can be dispensed with medication and thereby saved costs in the health system. For this purpose, continuous behavior monitoring by means of the use of health technology is preferably suitable – especially if these representations were conditioned on the basis of the previous simulation to the individually critical behavior parameters and therefore, as little as possible, act "as a teacher in the classroom" on the patient.

The societal relevance of the project is that many diabetics are affected by a type-specific, lasting and lasting behavioral change in terms of diet and exercise. Through knowledge-based care a low-threshold access to well-founded diabetes counseling is created. This advice and support is to be provided cost-effectively by the chosen approach. Telemedical or personal specialist consultations are only necessary in more complex situations. These can be carried out more efficiently due to the structured data situation. It would be desirable if the previously saved time could be used so that the doctor could spend more time on the patient.

Author's Statement

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