The Design and Development of a Computer Game on Insulin Injection

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Abstract
Background: Insulin therapy is of high importance in glycemic control and prevention of complications in type 1 diabetes in children. However, this treatment is unpleasant and stressful for many children, and it is difficult for them to accept. The purpose of the study was to design and develop an educational computer game for diabetic children to familiarize them with insulin injections.
Methods: After a review of the literature and the collection of basic information, we discussed the purpose of this research with some diabetic children, their parents, and nurses. The findings that we acquired from the discussion were considered in designing and developing the game. Then, following the principles associated with the development of computer games, we developed seven different games that related to insulin injections, and the games were evaluated in a pilot study.
Results: The games developed through the design and programming environment of Adobe Flash Player and stored on a computer disk (CD). The seven games were a pairs game, a puzzle game, a question and answer game, an insulin kit game, a drawing room game, a story game, and an insulin injection-room game). The idea was that diabetic children could become acquainted with insulin injections and the injection toolkit by playing a variety of entertaining and fun games. They also learned about some of the issues associated with insulin and experienced insulin injection in a simulated environment.
Conclusions: It seems that the use of new technologies, such as computer games, can influence diabetic children's acquaintance with the correct method of insulin injection, psychological readiness to initiate insulin therapy, reduction in stress, anxiety, and fear of insulin injection.

Keywords: children, diabetes mellitus type 1, insulin injection, computer game

1. Introduction
1.1. Background
Type 1 diabetes is one of the most common endocrine diseases in childhood (1). Epidemiologic studies indicate that the incidence of diabetes has increased by 2 to 5% around the world (2). The prevalence of diabetes varies in different nations and ethnic populations, with the greatest rate of diabetes occurring in Europe and northeast America. The lowest rates have been reported in China, Japan, and Finland (3). In Iran, the annual incidence of type I diabetes has been estimated to be 3.7 cases per 100,000 people (4). The most common age of onset of diabetes is

at 4 to 6 years or around adolescence at 10 to 14 years (1). Due to the functional defect of pancreatic cells in insulin production and increase in blood sugar levels (5), children with symptoms, such as polyuria, polydipsia, polyphagia, weight loss, and ketoacidosis are referred and hospitalized (6, 7). According to the American Diabetes Association, the goal of the treatment for type I diabetes in children and adolescents is to keep their blood sugar levels close to the normal range (7). With the discovery of insulin, a great revolution took place in the treatment and prevention of the complications of diabetes complications, including the death of children, so insulin therapy became a highly important treatment for this disease.

1.2. Statement of problem

Insulin injections and the respective educational points are initiated in a short time after the diagnosis of disease in children. However, when families and children are in shock, it is difficult for them to cope with the disease and accept the treatment (1, 10). Their concerns include the unfamiliar, stressful environment in the hospital (11), fear of the needles (12), and receiving multiple daily insulin injections. All of these factors can have serious, negative psychological effects on children (13, 14). Fear and anxiety due to insulin injections in diabetic children (15) and the respective behavioral reactions are a common and challenging problem because they lead to a lack of cooperation and verbal and physical protests at the time of injections at the beginning of insulin therapy (16). Researchers have found that making the children aware of the required medical procedures and teaching them to perform the procedures themselves reduce their anxiety and improve their cooperation (17). However, there is a paucity of research into this area of diabetic children. In Iran's hospitals, specific programs or interventions are not implemented to prepare children mentally or physically for the treatment regimen associated with their diabetes. If children's fear and anxiety are not handled properly, many negative effects can occur, including decreases in the frequency of testing to determine blood glucose levels, less insulin injections (18), anxiety disorders, depression (19, 20), and injection phobia. These issues, in turn, impact reduce the adherence to treatment and glycemic control regimen (21), produce family conflicts (22), require repeated hospitalizations (23), create negative attitudes among the parents and children toward disease (15), and decrease the children's quality of life (24).

Many researchers have proposed that medical games can be an effective and practical approach to prepare and control children's anxiety in order to perform the required therapeutic procedures (25). The purpose of the games is to promote children's level of adaptation during a medical procedure by acquainting them with the situation and the medical tools used to deal with it. This increases their sense of control and allows them the opportunity to express their fears, anxieties, and misunderstandings (25).

Today, modern technologies, such as computer games and video games have significant potential as useful instruments in the healthcare field as a result of their attractiveness, creativity, high quality and graphics, low cost and easy accessibility, interactivity, high excitement, enjoyment, and virtualization of the real world (26). The design, development, and use of software and computer games have attracted attention for promoting the physical and psychological health of children and adolescents who must undergo medical treatment for a persistent disease, such as typeI diabetes. Different games have been developed for diabetic children in this context, and they had positive results (27). However, such computer games are not available in the Persian language, and they were designed for teenagers with the aim of promoting self-care and self-management, so they cannot be used to assist Iranian children with diabetes. In addition, to date, no computer games have been designed using the Persian language to reduce anxiety or to familiarize children with insulin injections. Since the most likely age for diabetes to occur is in childhood (1) and preschool and school-age children usually have great fear and anxiety concerning therapeutic and medical treatment (28), it seems that the design and development of age-appropriate computer games related to insulin injection would be very beneficial in preparing diabetic children between the ages of three and 12 to accept insulin therapy.

1.3. Objectives
1.3.1. General objective
The purpose of the study was to design and develop a computer game for diabetic children to teach them about diabetes and insulin injections to decrease their fear and anxiety.
1.3.2. Specific objectives
The specific objectives of this research are listed below:
- To create a simulated environment to teach insulin injection skills to diabetic children
- To familiarize diabetic children with supplies and instruments needed for insulin injection
- To familiarize diabetic children with the insulin kit

- To decrease the fear, stress, and anxiety of diabetic children concerning insulin injections
- To teach diabetic children the correct way to perform an insulin injection

2. Materials and Methods
2.1. Initial data collection
In order to design the first phase of the game, we collected basic information about diabetes, insulin therapy (types of insulin, injection instruments, and injection technique), theories and learning theories (25), and cognitive and developmental growth in children three to 12 (1); also, different computer games were observed and considered.
For a more detailed design, semi-structured interviews were conducted with eight children in the age range of three to 12 who had diabetes and had been referred to the Endocrine and Metabolism Center and Imam Hossein Pediatric Hospital. This Hospital is a main center that provides health, therapeutic, and educational services to diabetic children in Isfahan. In the first phase of the study, children were asked to talk about why they felt anxiety and fear about insulin injections and their experiences of when insulin injections were initiated in the hospital. Then, in the second phase of the study, we collected the children's comments on their favorite features (e.g., characters, scenarios, colors) for use in designing computer games related to insulin injection. In addition, we interviewed the parents of diabetic children and the nurses who work in the pediatric ward about the problems of diabetic children in dealing with the insulin injections. The findings of these interviews were used to design and develop computer games.

2.2. Design and development of the computer game
We assembled a group of nurses, endocrinologists, child psychiatrists, graphic artists, and experts in development of computer games, and they performed their work at different stages. The development principles of computer games that were taken into account included the following (29):
- **Relevance:** a computer game must be related to its major development purpose. We designed our computer game in conjunction with the main purpose related to the insulin injection issue.
- **Goals of the game:** in designing and developing computer games in the health domain, short-term goals are required. We also considered short-term goals in designing the game so that the children could achieve goals, feel victory, and gain confidence in order to overcome their fears.
- **Feedback:** computer games must establish an interaction with the child and provide suitable feedback to their performance, choices, and decisions in the game, where necessary. In designing the game, voice and verbal feedbacks were given for the right or wrong behaviors and choices.
- **Individualization:** applicability of skills and abilities acquired in the virtual world and possibility of their transfer to the real world are key principles of the design of computer games. The options that are designed for the children in the games must be related to their options in the real world. Attempts must be made to design the game so that the children gain a sense of power and ability to manage their problems in the real world. In order for the game to be applicable in the real world, it must include the proper simulation of the stages of insulin injection and teaching strategies to control fear and anxiety about the injections.
- **Fun:** A game should be a pleasant activity and allow the participant to have fun. Such situations can be provided readily for children by a suitable design and utilization of technologies in the area of computer games. In in the design and development of this game, various topics were considered to enhance the children's motivation and create happy moments, such as a colorful and cheerful foreground, the use of various images and photos, and use of music the children would enjoy.

After considering the design principles of computer games and taking into account the results of the interviews and our literature review, the preliminary design of the game, the types of games, characters in the game, wallpapers used, the story, and the scenario were developed. Then, during several interactional meetings, dialogues, and negotiations, the game was programmed and designed with the help of a software expert who was familiar with computer games. According to the text and the dialogue, sound mixing was done by a sound recording team for all of the computer games. The design project and initial development of the game took six months.

2.3. Pilot study
After completing the development of the initial version of the game, it was stored on a CD and was provided to a number of diabetic children who were referred to the Isfahan Endocrine and Metabolism Center in order to watch and try all of the parts of the game. All children were satisfied with the type of games, foregrounds, colors, sound, and music. Due to some children's suggestions, the cartoon character of the insulin room game was changed to a

real character. This game was viewed by endocrinologists in the Isfahan Endocrine and Metabolism Center, and some parts of the images in the question and answer game were corrected based on their input.

2.4. Ethical considerations
The project to design and develop the game was approved by the Research Ethics Committee of Isfahan Medical Sciences University, Isfahan, Iran, license No.12/4/0.5/162. The Iranian informatics council gave software technical certificate No. 205407 to the computer game CD, and the Information Technology and Digital Media Development Center in the Ministry of Culture and Islamic Guidance issued its development license, No. 813991039430. Moreover, in terms of no adverse psychological impact on children (such as aggression, feelings of hopelessness, increased fear and anxiety, negative effects of dialogues and or story, color combinations) and scientific content, the game was confirmed by psychiatrist and specialists of diabetes in the Isfahan Endocrine and Metabolism Center.

3. Results
3.1. General findings
The results of the surveys and interviews showed that the reasons of most fears and poor cooperation of the children with the insulin injections were fear of pain, damage to the body, and the fatigue associated with its daily repetition. One eight-year-old girl stated, "I don't want to inject insulin, because I'm afraid of its needle." A four-year-old girl stated, "I did not let my mom inject insulin into my stomach, because I'm afraid of making a hole in my stomach." One six-year-old boy who was recently diagnosed with diabetes asked, "Why do I inject insulin?" According to the characteristics of computer games, most children preferred competitive and adventure games, cartoon characters, and human-like animation. The story of the game also was important to them, and they wanted the game to be designed in a medical setting, such as a hospital with a medical, attractive, funny, and happy scenario, and they wanted their medical questions on insulin and diabetes to be answered in this game.

According to the interviews with some nurses, one of the challenges they encountered when caring for diabetic children was the poor cooperation of children with the injection of insulin. Due to different responsibilities and heavy workload in the ward, nurses did not have sufficient opportunity to teach and prepare children. They believed that educational instruments must be pleasant, varied, and new for children, and computer games had better efficiency and effectiveness than traditional techniques, such as face-to-face education, manual, educational pamphlets, and practical exercise on a doll. Some mothers remarked that they accepted the responsibility of injecting the insulin for their children, but their children's resistance was very uncomfortable for them. Parents of diabetic children had a positive attitude toward the design and development of a computer game in order to familiarize children with insulin injection and to decrease their fear.

3.2. The computer game
3.2.1. Hardware aspects
This educational game is called "Koodak-e-Tavana." Adobe flash programming setting was used in this game that is run as a CD. According to the software structure, users need a minimum of hardware to run it. Its main file is as EXE application and does not need accessory software. The minimum hardware requirements to run the game are:
- Operating system (OS): MS Windows 98/2000/Me/XP/7/8
- Central processing unit (CPU): 3.0-GHz Intel Pentium or equivalent
- Random access memory (RAM): 1024 MB
- Video Card: 256 MB (AGP video card with DirectX 9.0 compatible driver)
- CD/DVD-Rom Speed: 8 xs
- DirectX: DirectX 9.0c or Higher.

3.2.2.   Content of computer games
3.2.2.1.   Background
The environment of the game is a combination of text, sound (speech-music), and fixed and moving images. Visual and auditory encouragement is offered by childish and funny voices, and points have been included to encourage the children, provide motivation, and their self-confidence. In addition, verbal notifications were regarded in the case of incorrect choices in the game. It is noteworthy that the way of doing games and conducting any activity that is required are described in simple words by a childlike voice, conveying to them that they also have the ability to overcome fears and control emotions in the world outside of the game. After running the software in the Windows operating system, a screen is displayed allowing the child to enter the main starting point by selecting the section "enter game." The main menu of the games selection was designed as a corridor in hospital with a number of rooms

that children can observe the game name as text and voice by scrolling the mouse on each room and then select their own favorite game by clicking on each room (Figure 1).

Figure 1. Play screen

3.2.2.2. The games
The seven games designed for the purposes of this study are as follows:

- **Game in pairs**

Instruments and equipment needed for the injection must be introduced at the first phase of children's familiarization with insulin injection process. This game aims to familiarize the children with the instruments and equipment needed for insulin injection. Game in pairs helps children become familiar with the injection instruments, such as vial, insulin regular, NPH insulin, insulin syringe, Glucometer device, and types of insulin injection pens and learn the name of each of these instruments. In this game, clicking on cards, observing the respective images, and familiarizing with its name, the child selects the appropriate card that has clicked on it. If the child selects the correct card, a star will be turned on the game screen and in this way, the child is encouraged to continue the game (Figure 2).

Figure 2. Game in pairs

- **Insulin kit game**

Instruments of insulin injection and the machine for checking blood glucose are considered as the imperative necessities of life of these children and they must learn to keep such instruments with themselves everywhere at all times. This game aims to familiarize the children with the insulin kit. In this game, children find instruments related to insulin injection through different medical instruments, and they put the intended instrument into the kit by

moving the mouse. If the children do these movements correctly, they will receive a certain point for encouragement to continue the game (Figure 3).
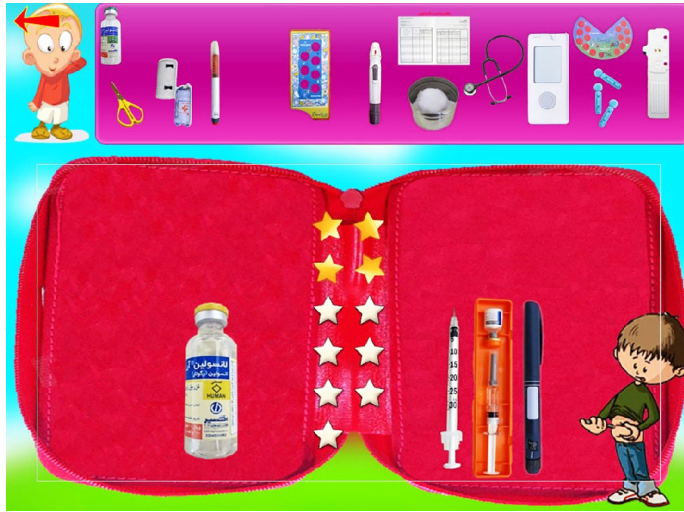

Figure 3. Insulin kit game

- **Drawing room game**

Drawing and painting are among the pleasant and joyful entertainments of children, and many researchers have referred to the role of drawing and painting in the reduction of anxiety in children. Painting different images in the game, children can exhibit their emotions, feelings, and concerns, and they can achieve a sense of freedom and relaxation. This game aims to use the drawing and painting technique to reduce children's stress. Three related and unrelated pictures of insulin injection are included for painting in this game. The painted drawings also can be printed so the child will have a copy to take home (Figure 4).
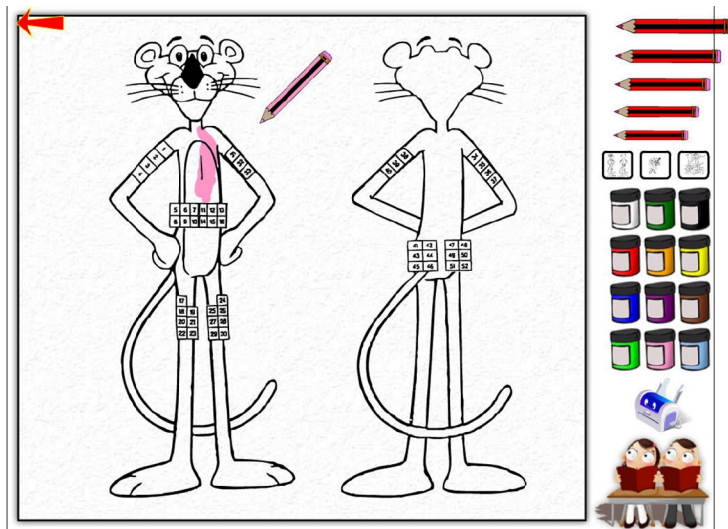

Figure 4. Drawing room game

- **Question and answer game**

Computer games are an effective method in the area of children's education. The question and answer game teaches children by considering the most important educational issues, such as how to keep insulin and the injection technique. The use of attractive pictures, animation, and music in this part of the game increases its effectiveness. This game aims at familiarizing the children with some educational topics on insulin injection. A series of questions and answers was used to achieve this goal. The questions can be viewed as speech and text, and the answers appear as cartoon pictures, short selectable animations, and real images. After posing the question, the child must select the

correct picture among two or four pictures. If the child selects the correct option, he or she receives a certain point to encourage the continuation of the game (Figure 5).

قبل از تزریق انسولین باید چیکار کنیم؟

Figure 5. Question and answer game

- **Little Ali story**
This game aims to reduce children's fear of insulin injection using the narration of a short story. Funny and attractive drawings are used to narrate the story. The main character of the story is a child with diabetes who does not allow anyone to inject insulin due to the fear of injection, but the child's fear, anxiety, and misunderstandings are overcome with the help and guidance of a nurse (Figure 6).

داستان علی کوچولو

Figure 6. Little Ali story

- **Puzzle game**
This game aims to reduce children's fear and anxiety by observing another child that has no fear of insulin injection. In this game, a child's picture is displayed who has no fear and anxiety and allows her mother to inject the insulin. Then, that picture is converted to a picture that has its parts scrambled. The child must connect the parts together to complete the picture (Figure 7).

- **Insulin injection room game**
This game aims at creating a simulated environment with a scenario in which the children inject the insulin and try to overcome their fear through the acquisition of skill and knowledge. After selecting the game environment (home, school, and hospital) and injection instruments (syringe, pen), children enter different stages of injection (e.g., insulin preparation, selection of injection site, and insulin injection) (Figure 8).
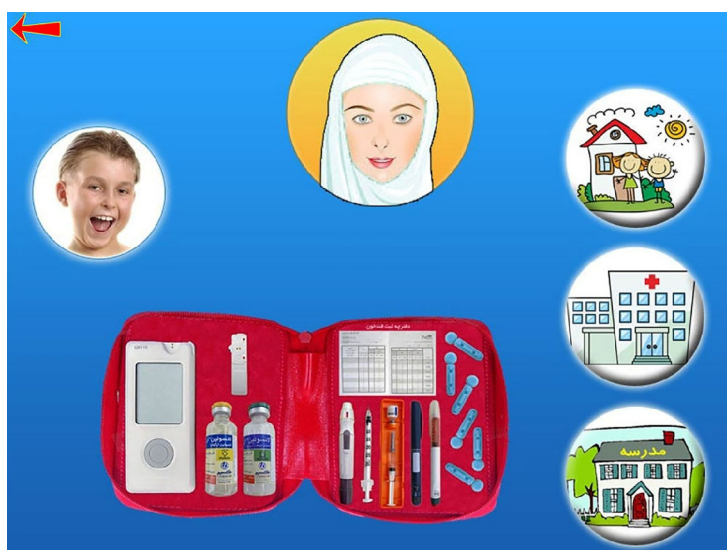
Figure 7. Puzzle game

Figure 8. Insulin injection room game

4. Discussion

Computer games have spread rapidly throughout the world over the past two decades, and they have become one of the three major entertainment industries (30). However, a number of researchers have expressed concerns on consequences and negative effects of computer and video games on children and adolescents. Some researchers also have emphasized the positive effects of computer games on children, e.g., their role in the development of some intellectual, mental, motion, and cognitive skills and learning improvement (31, 32) and problem-solving skills (33). The range and diversity of applications of this new technology has become very extensive in different domains. For instance, the computer game 'Asthma Files' had positive results in knowledge improvement and self-care of seven to 14-year-old children with asthma (34), and the video game 'Packy-Marlon' improved the self-care of diabetic children and adolescents (35). Researchers investigated the effect of the computer game 'Re-mission' on the increased level of knowledge and awareness of adolescents with cancer, including the care and control of the complications of the disease (24). In this game, the children's mission was to destroy cancer cells with weapons, such as medicine and nursing care (26). Some researchers believe that computer games could be useful for the treatment of children with psychotic disorders (36). In another study, Nilson et al. used video games as a distraction approach in order to decrease children's pain and anxiety (37). Moreover, it has been indicated that the use of computer games could have an effective role in the psychological preparation of eight to 12-year-old children for tonsillectomies and adenoidectomies, thereby decreasing their stress (38). It seems that the computer games

designed in our study, i.e., "Koodak-e-Tavana," can have positive consequences due to the characteristics used in its design and development.

One of the specific characteristics of this computer game is the use of a story (narration "little Ali") to convey educational concepts to diabetic children. It was demonstrated that the children enjoyed telling and listening to stories (39). Therefore, it can be expected that storytelling is an effective method to teach children, reduce their anxiety, improve their adaptation to different situations (40), and facilitate the transfer of complex medical concepts (41). The story of this game, which is derived from diabetic children's own experiences, visualizes children's anxieties and fears of diabetes and insulin injection. Thus, it helps them identify with the characters and recognize their feelings, emotions, and the reasons for their fears while creating story-like conditions in which they can accept and imitate the characters' behaviors and features. The nurse character in the story plays the role of a consultant and teaches the concept of diabetes, its importance, and the function of insulin in simple explanations, which helps to clear up the children's misunderstandings of insulin injections and teaches solutions, such as deep breaths and relaxation, in order to reduce the pain of the injections and control anxiety. Then story is made more impressive and meaningful by the use of music, the speech of the characters in the story, and the funny and childish images. Therefore, such storytelling, enhanced by the capabilities of modern technologies, such as computer games, can be very helpful in teaching children about disease, reducing their fear of injections, helping them to adapt, and improving the child-nurse relationships. The puzzle game is another very interesting feature of this game. According to Bandura's theory of observational learning, children can learn and imitate others' behavior through observation (42). Children follow patterns and peer groups are more influenced by learning through a patterned behavior that they observe (1). Hence, observing a child that allows her or his nurse or parents to inject her or him with no fear can be effective in reducing the anxiety and fear of children. The combination of this model with the puzzle game and or puzzle that is of interest to children brings us closer to the goal.

The insulin injection room is another feature of this computer game. One of the reasons for the popularity of computer games is the possibility of simulating different situations in the virtual world (30). Simulation of preparation stages, implementation of insulin injection, and existence of a scenario in which the child plays a role increases the child's motivation for learning. Providing medical information in a simulated environment that is pleasant and allows the children to have fun helps reduce their distress and fear of insulin injections. This game can improve children's adherence to their insulin therapy, resulting in better control of blood sugar and preventing physical and psychological problems by allowing them to transfer and apply the knowledge and skills acquired in the virtual world to their real-world situations. Thus, they can cooperate in the preparation the injection instruments and in administering the injections in the real world, possibly doing the injections themselves. When the children wins the game for proper administration of injections, the accompanying visual and auditory encouragement will increase their confidence, giving the ability to overcome fears and control emotions in the real world outside of the game.

5. Conclusion
It seems that use of various games, application of attractive stories, and utilization of interesting computer techniques, such as sound, video, and animation can influence diabetic children's familiarization with the correct way of insulin injection. It also contributes to the proper psychological readiness of diabetic children for initiation of insulin therapy and decreasing the anxiety, stress, and fear of insulin injection. However, further experimental studies should be conducted to assess the impact of this game on the quality of life of diabetic children and their optimal treatment through insulin injections.

Conflict of Interest:
There is no conflict of interest to be declared.

Authors' contributions:
All of authors contributed to this project and article equally. All authors read and approved the final manuscript.

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