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Designing and Development of an Oral Health Educational Game and Evaluation of Its Effect on 8-12-Year-Old Children's Oral Health: A Randomized Clinical Trial

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Objectives Health education for school-age children is a specialized component of the oral health promotion program. This study aimed to design and develop an oral health educational game and assess its effect on the oral health of children aged 8 to 12 years.
Methods In this experimental study, 40 patients aged 8-12 years referring to a private dental clinic were selected by using convenience sampling and were then randomly assigned to the experimental and control groups. The experimental group received oral health training by using a game; while, the control group received oral hygiene instructions. The simplified oral hygiene index (OHI-S) with two components of debris index (DI-S) and calculus index (CI-S) was measured before the intervention, and at one week, and one month after the intervention to assess the effect of oral health skills. Data were analyzed by the Chi-square test, independent sample t-test, and Fisher's exact test.
Results The DI-S scores in the experimental group at one week and one month after the intervention were significantly lower than the values in the control group (P=0.003 and P=0.001, respectively). The OHI-S scores in the experimental group at one week and one month after the intervention were significantly lower than the values in the control group (P=0.012 and P=0.007, respectively). No significant difference was noticed in the follow-up CI-S scores at one week and one month after the intervention (P>0.05).
Conclusion The game designed in this study would improve the children's oral health skills; hence, it can be used to promote oral health in children.
Keywords Oral Health; Health Education; Dental Plaque Index; Child

Introduction

Oral health is one of the main branches of public health, and oral health promotion is one of the programs of the World Health Organization in the field of chronic disease prevention and health promotion. [1] A variety of diseases and conditions are classified as oral diseases, including dental caries, periodontal diseases, oral cancer, noma[1] , dental lesions, and fluorosis.[2] The modern lifestyle and eating habits have increased the prevalence of caries in today's world. Also, 99% of people suffer from dental caries during their lifetime, and about 37% of teeth are lost due to caries.[3] Dental plaque is the primary cause of caries and periodontal disease, and cannot be removed simply by gargling water or spraying water or air. It must be removed mechanically with a toothbrush. [4] The aim of oral hygiene is to remove the microbial plaque from all dental surfaces.[1] Caries, like most oral diseases, does not stop or disappear spontaneously; and its examination, diagnosis, and treatment require dental check-ups. Dental caries can lead to tooth loss if left untreated. Also, it affects the facial appearance, quality of life, nutrition, and ultimately growth and development of children.[5] Tooth decay is one of the most common chronic and infectious diseases in childhood as 60-90% of primary school children suffer from dental caries worldwide. [1] Primary caries is a common disease in children that causes chewing problems, loss of appetite, weight loss, sleep problems, behavioral changes (e.g., moodiness and low self-esteem), and poor academic performance.[6] Children are supposed to shape the society's future; thus, their physical, mental, and social health ensures a brighter future. Accordingly, strategy planning is necessary to ensure children's health and promote the community's health status.[7] All countries have spared their efforts to ensure the health of different groups in the society. In this regard, since students are the future-makers in any society, they are considered as human resources, and special attention should be directed to their oral health.[8] Health education aims to teach the school children about how to prevent oral health problems.[9] Health education skills should enable an individual to make positive decisions using one's knowledge, attitude, and skills and adopt the necessary measures to promote individual and public health.[10] Game-based education is an educational strategy reinforcing the children's learning in a dynamic and encouraging manner. It is also an alternative technique for teaching basic health concepts. Games bring about several benefits for children, such as enhancing their visual intelligence and attention and assisting memory and reasoning strategies. [9] Since learning has a social dimension and is rooted in social interactions, the educational benefits of the games are potentially more evident in multi-player social games.[11] Many studies have examined the effectiveness of games in improving oral health and investigated their effects on oral health awareness and skills worldwide. [9, 12, 13] In India, for example, Kumar et al. (2015) compared traditional and game-based oral health education. After 3 months, they noticed that the rate of reduction in debris and increase in oral health was higher in the game-based education group.[9] In another study in India, Malik et al. (2017) documented that plaque reduction and oral health promotion were greater in a

[1] The disease is caused by acute malnutrition and usually affects individuals with lower socioeconomic classes.

group of children who had been trained to play games.[12] According to Aljafari et al. (2017), game-based education can be as effective as face-to-face training in conveying oral health concepts. [13] In Iran, however, few studies have addressed oral health education. To fill this gap, the authors of the present study decided to take measures to promote oral health by developing and producing an innovative educational game and assessing its impact on oral health of 8-12-year-old children. The findings of the present study would help the healthcare providers and higher-level health education authorities in Iran to use educational games in the educational system of health centers, dental clinics, schools, and so on, as an affordable educational aid.

Methods and Materials

This clinical trial was conducted in two steps. In the first step, the graphic design of the game engineering was performed using Photoshop software version 2018. The designed game contained game pieces, a sheet, and question cards, which was approved by the National Toy Supervision Council (Code number:99.2363557.2) as a competitive, entertaining group game in accordance with the dominant local culture of Iran. The game was designed in color format on a cardboard sheet to be played step by step by rolling the dice and moving the game pieces. This educational game was designed to empower the cognitive learning and skills of children and was a modification of the Snake & Ladder game, improved with question cards and a dental model to improve the practical skills. The game was developed based on the educational concepts of oral health in children by addressing proper techniques of toothbrushing and dental flossing, familiarity with healthy foods, factors leading to oral diseases, suggesting dental visits, and so on. This information was adopted from valid and up-to-date sources and was incorporated in the game pieces and question cards. Each game training package included a game sheet accompanied by a manual, a dental model with a toothbrush, an educational brochure for parents, a CD containing educational clips, 16 question cards with answers, four game pieces, and one dice. The experimental group received the package in the first session, and its effect on children's oral health was evaluated during the research period (Figure 1).

Figure 1- Components of the educational game

In the second step, 40 patients aged 8-12 years referring to a private dental clinic in autumn 2019 were selected by convenience sampling and randomly assigned to the experimental and control groups (Figure 2).

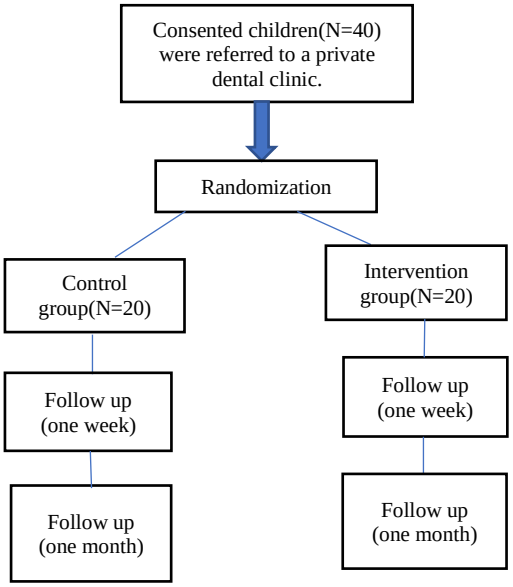

Figure 2- Flow chart of the study

Permuted block randomization was used to allocate the two study groups to the intervention and control groups. Six permutations were utilized with blocks of four including ABAB, AABB, ABBA, BAAB, BABA, and BBAA (A: intervention group, B: control group). The sample size was calculated based on a type I and type II error of 0.05 and 0.20, respectively, and also a large effect size of 0.5-1.0. [14]

The experimental group received game-based training. In the experimental group, the children and their parents took part in an informatory session and received some explanations about the game. In the waiting room, the child was shown how to play the game by the healthcare provider (researcher) acting as a facilitator. It took about 30 minutes to complete the game. The game was then given to the children for home practice and repetition, with a focus on parental supervision and parents playing with their children. Oral hygiene instructions alone were provided to the control group. The parents gave their consent to participate in the study by signing an informed consent form. The study was also approved by the ethics committee (No: IR.ZUMS.REC.1398.451) of the university and registered in the Iranian Registry of Clinical Trials (IRCT20210911052431N1). To assess the oral health of the control and experimental groups, The Greene and Vermilion's oral hygiene index-simplified (OHI-S)[15] was measured by a trained researcher who was blinded to the group allocation of children in three phases namely before the intervention, at one week after the intervention, and at one month after the intervention. The findings were then compared. The OHI-S index has two components: the debris index simplified (DI-S) and the calculus index simplified (CI-S). Both indices are based on numerical scales. In order to calculate the indices, a dental explorer was used to assess the status of the teeth in terms of presence of debris and supragingival, and subgingival calculus. A set of scoring criteria was used for these indices. The sum of the values of the two indices indicated the OHI-S score. The amount of debris and calculus on the labial surface of the teeth #11, 16, 26, 31 and lingual surface of the teeth #36

and 46 was quantified for the OHI-S.[15] The inclusion criteria were complete eruption of teeth examined in the OHI-S, including at least one of the upper and lower incisors and at least one of the permanent teeth of the right quadrant of the lower dental arch or similar adjacent teeth. Children out of the age range of 8-12 years, those with mental disabilities, illiterate in reading and writing, unfamiliar with the Persian language, using antimicrobial mouthwashes or having fixed orthodontic appliances were excluded from the study. A checklist was used to collect the required data, in which the information about the plaque and calculus index required to calculate the OHI-S index as well as the values of the OHI-S index were recorded. To examine the reliability of the collected data (inter-rater reliability), the correlation coefficient between the two measures for the OHI-S index was calculated to be 0.93. The OHI-S has been reported as a valid benchmark to determine oral health.[16] Moreover, two experts from the field performed all the measurements who were blinded to the group allocation of children.

Statistical analysis

Data were analyzed using SPSS version 19 by the Chi-Square test, Independent-sample t-test, and Fisher's exact test. The data distribution was found to be normal. As a result, parametric tests were applied. We also conducted a mixed model on three oral health indices. The within and between subject effects were evaluated. Moreover, the interaction between the within and between subject effects was also reported (oral health indices and study group). The sphericity assumptions were evaluated using the Mauchly's tests and the related analysis based on this test was conducted.

Results

The results revealed no significant difference between the experimental and control groups in terms of demographic characteristics, including the frequency distribution of gender, father's and mother's level of education, and father's and mother's occupation (P>0.05, Table 1).

Table 1- Demographic features of the participants

	Subcategories	Frequency (percentage)		Sig.
		Experimental group	Control group	
Gender	Male	8 (40)	10 (50)	0.751
	Female	12 (60)	10 (50)	
Father's level of education	Illiterate	0 (0)	0 (0)	0.741*
	Elementary school	0 (0)	0 (0)	
	Diploma	8 (40)	6 (30)	
	Academic	12 (60)	14 (70)	
Mother's level of education	Illiterate	0 (0)	0 (0)	0.337*
	Elementary school	0 (0)	0 (0)	
	Diploma	10 (50)	7 (35)	
	Academic	10 (50)	13 (65)	
Father's job	Employee	10 (50)	5 (25)	0.191
	Self-employed	10 (50)	15 (75)	
Mother's job	Housewife	12 (60)	13 (65)	0.744
	Employee	8 (40)	7 (35)	

* Fisher's exact test was used.

The scores of DI-S index were significantly lower in the experimental group than in the control group at one week and one month after the intervention (P=0.003 and P=0.001, respectively). Moreover, the OHI-S scores were significantly lower in the experimental group than in the control group at one week and one month after the intervention (P=0.012 and P=0.007, respectively, Table 2).

Table 2- Mean and standard deviation of DI-S, OHI-S, and CI-S scores

Variable	Mean± standard deviation		Sig.
	Experimental group	Control group	
DI-S score			
Before the intervention	1.35±0.57	1.29±0.64	0.740
One week after the intervention	0.61±0.34	1.02±0.46	0.003
One month after the intervention	0.52±0.20	0.94±0.47	0.001
CI-S score			
Before the intervention	0.09±0.17	0.06±0.16	0.620
One week after the intervention	0.07±0.13	0.06±0.16	0.640
One month after the intervention	0.07±0.13	0.06±0.16	0.640
OHI-S score			
Before the intervention	1.44±0.71	1.35±0.74	0.608
One week after the intervention	0.68±0.35	1.08±0.57	0.012
One month after the intervention	0.59±0.24	1.00±0.58	0.007

At one week and one month, the variations of the DI-S and OHI-S scores were more significant in the experimental group than in the control group as the scores revealed a more significant reduction in the experimental group (Table 3).

Table 3- Variations of DI-S, OHI-S, and CI-S scores

Variable	Mean± standard deviation		Sig.
	Experimental group	Control group	
DI-S score			
Variations at one week vs. before the intervention	0.74±0.69	0.27±0.28	0.007
Variations at one month vs. before the intervention	0.82±0.57	0.35±0.26	0.002
Variations at one month vs. at one week	0.08±0.18	0.08±0.19	0.980
CI-S score			
Variations at one week vs. before the intervention	0.01±0.05	0.00±0.00	0.155
Variations at one month vs. before the intervention	0.01±0.05	0.00±0.00	0.155
Variations at one month vs. at one week	0.00±0.00	0.00±0.00	1.000
OHI-S score			
Variations at one week vs. before the intervention	0.76±0.71	0.27±0.28	0.007
Variations at one month vs. before the intervention	0.84±0.60	0.35±0.26	0.002
Variations at one month vs. at one week	0.08±0.18	0.08±0.19	0.940

In the mixed model, regarding the DI-S index, the Mauchly's statistics showed that there was evidence of heterogeneity of covariance (Mauchly's W=0.300, approximate Chi-square=46.60, df=2, P<0.001). As a result, we conducted the analysis based on the Greenhouse-Geisser non-sphericity hypothesis. In assessment of the within-subject effects, the times of evaluation showed a significant association with DI-S [F (1.18, 44.69) =47.48, P<0.001, partial eta squared=0.555]. In assessment of interactions, there was a significant interaction between the time of evaluation (three measurements of DI-S) and the study group [(F (1.18, 44.69) =8.806, P=0.003, partial eta squared=0.188]. Our results also showed a significant result in assessment of between-subject effects [(F(1, 38) =5.74, P=0.047, partial eta squared=0.178].

In assessment of the CI-S index, the Mauchly's statistics showed that there was evidence of heterogeneity of covariance (Mauchly's W=0.300, approximate Chi-square=46.60, df=2, P<0.001). As a result, we conducted the analysis based on the Greenhouse-Geisser non-sphericity hypothesis. In assessment of the within-subject effects, the time of evaluation did not show any significant association with the DI-S index [F (1.18, 44.69) =2.11, P=0.155, partial eta squared=0.053]. In assessment of interactions, there was no significant interaction between the time of evaluation (three measurements of the CI-S index) and the study group [F (1.18, 44.69) =2.11, P=0.155, partial eta squared=0.053]. Our results did not show a significant finding in assessment of between-subject effects [[(F (1, 38) =0.148, P=0.703, partial eta squared=0.004].

When the mixed model was conducted on the OHI-S index, similar to other indices, the Mauchly's statistics showed evidence of heterogeneity of covariance (Mauchly's W=0.286 approximate Chi-square=46.27, df=2, P<0.001). Thus, the analyses were performed based on the Greenhouse-Geisser non-sphericity hypothesis. In assessment of within-subject effects, the time of evaluation showed a significant association with the DI-S index [F (1.17, 44.35)=46.30, P<0.001, partial eta squared=0.549]. In assessment of interactions, there was also a significant interaction between the time of evaluation (three measurements of OHI-S index) and the study group [F (1.17, 44.35)=8.96, P=0.003, partial eta squared=0.191]. However, our study did not show a significant result in assessment of between-subject effects [(F (1, 38) =2.10, P=0.155, partial eta squared=0.052].

Discussion

According to the results of the present study, in addition to a significant decrease (p <0.05) in the scores of DI-S and OHI-S in both the intervention and control groups at the end of the study, variations were observed more frequently in the experimental group than the control group. It can thus be concluded that the content of the produced game was effective in teaching oral hygiene to children. In a study by Hapsari et al, examining the oral health status of orphans using the OHI-S index, the DI-S and the OHI-S index scores revealed a significant decrease in the post-intervention evaluation. However, the CI-S index scores were not different before and after the intervention. This finding was completely in line with that of the present study. Their study, however, was different from the present study in terms of the health training technique, the presence of a control group, and the follow-up period.[17]

In a study by Kumar et al, which aimed to investigate the effect of game-based education on children's oral health performance using the DI-S index, the results were consistent with those of the present study. The findings revealed a decrease in the DI-S score at one week and one month after the intervention compared with the pre-intervention state. However, the variation rate in their study was significantly higher until the first week; but, the rate decreased during the follow-up period. In the present study, the variations of the DI-S decreased until one month after the intervention and in addition to the DI-S index, the variations of the CI-S and OHI-S indices were also evaluated. Another difference between their study and the present study was the presentation of games for 7 days, once a day, to the children in the experimental group. In contrast, the game in the present study was given to the children and parents to increase their awareness and practical skills by playing and practicing it at home.[9]

Maheswari et al. used the DI-S index to evaluate the effectiveness of oral health training provided by Snake and Ladder game. In their study, there was a significant increase in the DI-S score of both the control (8-10-year-olds) and experimental (7-5 and 8-10-year-olds) groups one day after the intervention and three months later. In the control group (5-7-year-olds), however, no significant change was noted. Despite the similarity of the findings of their study with those of the present study, in the present study, In addition to the DI-S index, the variations of the CI-S and OHI-S indices were also evaluated. This is one of the strengths of this study, compared with that of Maheswari et al. In the present study, assessments were performed at one week and one month after the intervention, which is different from the study by Maheswari et al.[18]

De Farias et al. conducted a study to assess the effect of oral health education program on primary children’s oral health. In their study, oral health was measured before the intervention and at one month after the intervention using the visible plaque index and gingival bleeding index for each student. After performing evaluations at the end of the study, the two indices were significantly lower in the experimental group. In the control group, however, the visible plaque index showed a significant decrease (P=0.001). The findings of their study were in line with those of the present study even though there were some differences in the methods of teaching health concepts, clinical evaluation method, and the concerned indices. Furthermore, the follow-up of the patients in their study was only once (i.e., one month after the intervention); however, the follow-up in the present study was at one week and one month.[19] Makuch and Reschke examined the effectiveness of games in improving the children’s dental health and found similar results. The variations in children's health behaviors in their study were assessed by a trained

observer considering children's toothbrushing skills. Prior to the intervention, all children in the experimental and control groups had almost the same skills, and there was no difference between the two groups. When the children were examined 5 and 10 weeks after the intervention, the children in the experimental group showed better oral hygiene skills than those in the control group. However, the two experimental groups had no significant difference. Their study and the present study were different in terms of techniques for teaching health concepts, clinical assessment of children's oral hygiene, and follow-up periods.[20]

In a similar study, Malik et al. compared the effectiveness of game-based oral health education with a PowerPoint presentation in the field of oral health and assessed the effect of this type of education on the practical skills of children participating in the study using the modified Quigley-Hein index before, one month, and three months after the intervention. The results were in line with those of the present study. In both studies, a decrease in plaque score was observed in both the control and experimental groups after the intervention, and there was also a further decrease in plaque score in the experimental group, compared with the control group. In spite of the similarities in the findings, the techniques of teaching health concepts and clinical evaluation were different in the two studies using different indicators. Another difference between their study and the present study was the presentation of games for 7 days, once a day, in a dental clinic to the children of the experimental group. However, in the present study, in addition to playing with the children in the experimental group and their parents in a private clinic, the game was given to the children and their parents to increase their awareness and practical skills by playing and practicing it at home.[12]

Bhardwaj et al, also assessed the impact of a health education program on students using the Silness and Loe plaque index, the Silness and Loe gingival index, and the World Health Organization modified DMFT index before the intervention and 3 months after the intervention. According to their findings, the plaque and gingival scores significantly decreased after the intervention; however, no significant difference was observed in the mean scores of caries before and after the intervention. Despite the effectiveness of this training program, there was no control group in their study to ensure the effect of this training program. The findings of this study were in line with those of the present study in terms of the effectiveness of the educational program. Despite the differences in the techniques of teaching health concepts and the use of different indices in clinical evaluation, absence of a control group was the weakness of their study.[21] In a study by Dowey, the effect of computer-based health education on primary school children was assessed using the modified Quigley-Hein index before the intervention, one week after the intervention, and one month and three months after the intervention. The findings supported those of the present study since there was no significant improvement in oral hygiene in the intervention and control groups. In this study, the techniques of teaching health concepts and clinical evaluation of children's oral health skills were different from those in the present study.[22]

Nameni et al. investigated the impact of card game training and assessed the participants' oral health awareness and behaviors using a questionnaire. They detected a significant increase in the mean scores of awareness in both the experimental and control groups immediately after the intervention and one month later. Moreover, the behavioral changes in children's oral health were not statistically significant one month after the intervention in both groups. In their study, the method adopted to assess oral health-related behaviors differed from that of the present study (questionnaire vs. clinical assessment method), and the difference was also statistically significant. The game was played once a week for one month in the experimental group in their study. However, the game in the present study was provided to the children and parents to increase their knowledge and practical skills by playing and practicing it at home during the study period.[23]

Similar studies investigating the effect of educational content on oral health used different techniques. In some studies, the variations in health behaviors were assessed using a questionnaire and by asking questions; however, some other studies adopted clinical assessment methods. In some studies, only variations in children's knowledge and awareness were addressed, and different indices were used for clinical assessment. This study evaluated the clinical effect of game-based oral health education by assessing practical skills.

Our study had some limitations. Since there was no previous study with an intervention similar to ours, we calculated the sample size based on an assumed large effect size due to the limitations of the COVID-19 pandemic, which made access to adequate sample size impossible. However, even with a small number of samples, our study showed a significant relationship between our intervention and some of the desired outcomes. As mentioned earlier, our study was conducted as a single center study with a relatively low sample size, which decreases the generalizability of the study results and thus its external validity. Therefore, future studies are recommended on a larger sample size to examine the participants' knowledge and attitude towards this educational game.

Conclusion

In the present study, there was a significant decrease in the DI-S index and OHI-S scores in both the experimental and control groups at the end of the study; however, the decrease was more significant in the experimental group than the control group. Since this innovative game was successful in improving the children's oral health skills, it can be used to promote oral health of children.

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Conflict of Interest

No Conflict of Interest Declared ■

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