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The Effect of Using Fluorescent Concretization Intervention on Hand Hygiene Training in Primary School Students

İlkokul Öğrencilerinde Floresan ile Somutlaştırma Girişiminin Kullanılmasının El Hijyeni Eğitimine Etkisi

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ABSTRACT

Introduction: Inadequate hand hygiene increases the rates of childhood infectious diseases and deaths, leading to the death of one child per minute.
Aim: The aim of the study was to examine the effects of the program in which fluorescent embodiment intervention was used as an educational strategy on the hand washing skills of primary school students.
Method: Single center randomized controlled trial using a pretest and posttest design was conducted with 35 intervention and 35 control participants. Data were collected with Dermalux Test Lotion containing fluorescently detectable under ultraviolet light, Sociodemographic Data Questionnaire, Hand Washing Skill Checklist, Hand Washing Skill Efficacy, and Hand Hygiene Assessment Question Form in School Children.
Results: A statistical difference was found in the hand washing activity given for both hands of the participants in the experimental group before and after the training ($p < 0.001$). There was an increase in the mean hand washing checklist scores and hand washing times of all participants before and after the training ($p < 0.05$). When the percentage of change in the mean hand washing checklist scores before and after the training was compared, it was found that the change in the experimental group increased to 62% and in the control group to 23% ($p < 0.001$).
Conclusion: Visual concretization and explanation improve hand washing activity. Therefore, it is highly recommended to use technological devices that provide such visual feedback in the education of school-age children.

Keywords: Education; hand hygiene; hand washing; school nursing.

ÖZ

Giriş: Yetersiz el hijyeni nedeniyle çocukluk çağındaki bulaşıcı hastalık ve ölüm oranları dakikada bir çocuğun ölümüne yol açmaktadır.
Amaç: Eğitim stratejisi olarak floresan ile somutlaştırma girişiminin kullanıldığı programın ilkokul öğrencilerinin el yıkama becerileri üzerindeki etkilerini incelemektir.
Yöntem: Ön test ve son test desenli, tek merkezli randomize kontrollü çalışma, 35 deney ve 35 kontrol katılımcısıyla yürütüldü. Veriler, ultraviyole ışık altında floresanla tespit edilebilen Dermalux Test Losyonu, Sosyodemografik Veri Formu, El Yıkama Beceri Kontrol Listesi, El Yıkama Beceri Etkinliği ve Okul Çocuklarında El Hijyeni Değerlendirme Soru Formu ile toplandı.
Bulgular: Eğitim öncesi ve sonrası deney grubunda yer alan katılımcıların her iki el için verilen el yıkama etkinliğinde bölgelere göre istatistiksel fark tespit edilmiştir ($p < 0,001$). Eğitim öncesi ve sonrası tüm katılımcılarda el yıkama kontrol listesi puan ortalamalarında ve el yıkama sürelerinde artış tespit edilmiştir ($p < 0,05$). Eğitim öncesi ve sonrası el yıkama kontrol listesi puan ortalamaları değişim yüzdesi karşılaştırıldığında deney grubundaki değişimin %62'ye, kontrol grubundakinin ise %23'e yükseldiği tespit edilmiştir ($p < 0,001$).
Sonuç: Öğrencilere görsel somutlaştırma ve açıklama yapılması ile el yıkama etkinliğini geliştirmektedir. Bu nedenle okul çağındaki çocukların eğitiminde bu tür görsel geri bildirim sağlayan teknolojik cihazların kullanılması önemle tavsiye edilmektedir.

Anahtar Kelimeler: Eğitim; el hijyeni; el yıkama; okul sağlığı hemşireliği.

Introduction

School-age or school years begin with entrance into the school environment, significantly impacting children's development, relationships, biological, social, emotional, cognitive health and well-being (Black et al., 2021). Primary schools are the first environment where children are present collectively; therefore, they pose a high risk of transmission of infectious diseases (Mbakaya, Lee & Lee, 2017). Children spend more than half of a year in the school environment, breathe the same air as many students of various age groups, and touch many risky surfaces, especially in classrooms, toilets, canteen, and school surroundings. In this chain, students' hands are the most common fomite, which paves the way for the transfer of microorganisms to school and their reproduction at school (Behzadkolaee et al., 2015). Children of school age are much more defenseless to infectious conditions than adults since their immune systems are immature, and they spend most of their time in the school environment (CDC, 2019). Effective hand washing has been at the center of all infection control measures during the last pandemic period and during illnesses and flu epidemics and is of great importance, especially for school children (Wong & Lee, 2019).

Hand hygiene (HH) is the primary measure for controlling infectious diseases and is an easily applicable, low-cost method that is well-accepted worldwide (Canton, 2021). Hand washing is described as "the most important hygiene measure in preventing the spread of infections" when performed with soap and water (WHO, 2009). In a study, it was reported that the rate of hand washing using soap in school children was 66%, that the rate of hand washing at the recommended time was 58%, and that the rate of correct hand washing decreases at younger ages (Thanh Xuan & Hoat, 2013). In another study, only 42% of students showed good hand washing behavior (Chen et al., 2020). All these findings have shown that the rate of correct hand washing in school children is not at the desired level. Furthermore, according to some findings, inadequate hand hygiene increases the rates of childhood infectious diseases and deaths, leading to the death of one child per minute (WHO, 2012; Mbakaya, Lee & Lee, 2019). Since it is more likely to ensure appropriate HH behavior at an early age, any attempt to develop this behavior in children gains importance, especially in the first stage of education (McMichael, 2019). Because, unlike adults, children have less established negative hygiene habits. This age group does not have stereotyped and hard-to-change habits and thus, is much more likely to acquire positive behaviors (Mbakaya et al., 2017). For this reason, studies published in the last five years have mostly focused on improving HH in primary schools (Biswas et al., 2019; Mbakaya et al., 2019; Chen et al., 2020; Ozcan, Ozdil, Kaya & Sezer, 2020; Öncü & Vayısoğlu, 2021; Berhanu et al., 2022). In the literature, different methods such as free delivery of soap (Nicholson et al., 2014), delivery of hand sanitizers with alcohol content classrooms (Priest et al., 2014), stimulation-based initiatives (Dreibelbis, Kroeger, Hossain & Venkatesh, 2016), virtual reality (creation of microbe images on hands and their disappearance with correct hand washing practices) (Shimada, Funahashi, Ito & Tanase, 2017), peer education (Ákos et al., 2018), hand washing workshop (training, video demonstration, puzzle making) (Alzaher, Almudarra, Mustafa & Gosadi, 2018), video-based games (Kang & Chang, 2019), hand hygiene programs with various contents (Mbakaya et al., 2019), multi-faceted skill training (puzzle, song, performance, dance) (Ozcan et al., 2020), establishment of hand washing stations in areas with limited access to sources (Mbakaya, Kalembo & Zgambo, 2020), minimalist social robot concretization (common design of a simple social robot that motivates HH practices in children) (Pasupuleti et al., 2023) have been used to improve children's HH behavior in schools in Turkiye and in the world.

Aim

Primarily, this study aimed to examine hand washing effectiveness according to the area, hand washing psychomotor skills, and duration of hand washing in school age children before and after the HH training given through fluorescent concretization intervention. The secondary aim of the study was to evaluate the effect on hand hygiene attitude, perceived behavioral control, subjective norm, and hand washing intention and behavior in school children before and after the training.

Hypotheses of the study

H_{0-1}: There is no difference between the groups in hand washing effectiveness before and after the HH training given with fluorescent concretization intervention in school children, depending on the area, hand washing psychomotor skills and hand washing duration.

H_{1-1}: There is a difference between the groups in the hand washing effectiveness before and after the HH training given with fluorescent concretization intervention in school children, depending on the area, hand washing psychomotor skills and hand washing duration.

H_{0-2}: There is no difference between groups on HH attitudes, subjective norm, perceived behavioral control, hand washing intention and behavior in school children before and after training.

H_{1-2}: There is a difference between groups on HH attitudes, subjective norm, perceived behavioral control, hand washing intention and behavior in school children before and after training.

Method

Study Design

This single-centre randomized controlled trial using a pretest and posttest design was conducted in accordance with the CONSORT guidelines. Figure 1 shows the CONSORT flow diagram, which includes the study's methodology as well as the enrollment and student follow-up processes (Figure 1).

Study Setting

The study was conducted with the students who undergone primary school during the period of February and June 2023. Since the interventions in the early years were more effective in developing positive health behaviors, the research population consisted of second year students (n = 280).

Study Population and Sample

First-grade students were excluded as they might have difficulty reading and writing. Schools that committed to taking part in the

study invited their second-grade students who are typically between the ages of 7 and 8 by sending out letters of information about the study to the students' parents or caretakers. Students who had not received previous HH training on UVA light, whose skin integrity was not visibly disrupted on the hands, who had one year, or more reading-writing experience were included in the study.

The sample size of the study was calculated using G*Power software (Faul et al., 2009) with a margin of error of 0.05 and a statistical power of 0.80, with a medium effect size of 0.7 (International Committee of Medical Journal Editors, 1997), and 34 students each for the intervention group and control group. In the preliminary study conducted to calculate the sample size, the effect size was determined as 0.68 with a power of 80% and a significance level of 5% between group 1 and group 2 in terms of applied test scores. As a result, the number of students to be included in the study was determined as 70 (intervention and control). Seven participants withdrew from the study after it was allocated, leaving a total of 77 participants, 35 in the intervention group and 35 in the control group completed in the study.

Among the 44 primary schools in the Nilüfer district of Bursa Province in Turkey, 17 schools with low socioeconomic status were determined. A school selected by simple random sampling was chosen as the location where the research would be taking place. Since the fluorescent lotions purchased from abroad were covered by the authors without research funding, only one school could be selected. Then, the simple randomization technique was used to allocate participants into groups. Envelopes including the students' names were placed in a box and mixed thoroughly. The envelopes were chosen by lot and the students were divided into two groups: intervention and control. While it was not possible to blind the principal investigator, the second investigator who performed the follow-up and the students, due to the design and nature of the study, were blinded to the groups.

Data Collection Tools

The data of the study were collected with Sociodemographic Data Questionnaire, Hand Washing Skill Checklist (HWSC), Hand Washing Skill Efficacy (HWSE), Hand Hygiene Assessment Question Form in School Children (HHAQSC).

Sociodemographic Data Questionnaire: The questionnaire contained questions on gender, whether the student needed hand hygiene training, whether the student received hand hygiene training at school, whether soap and water were necessary to clean microbes, and nail length. The form was prepared in line with the literature to determine participants' socio-demographic characteristics and their level of knowledge of hand hygiene (Biswas et al., 2019; Mbakaya et al., 2020; Uyanık & Dağhan, 2022).

Hand Washing Skill Checklist: The checklist was prepared in line with the instructions of the World Health Organization and Center for Disease Control and Prevention guidelines (WHO, 2009; CDC, 2016). It includes 14 procedural steps. This is not a scale, and the Turkish translation was used. A procedural step in the checklist that was not performed was scored 0 points; a step that was incorrectly performed was scored 1 point; a correctly performed step was scored 2 points. The lowest score obtainable from the checklist is 0 and the highest score is 28 (Şimşek, 2012). In this study, Cronbach's α value was found to be 0.809 for the HWSC.

Hand Washing Skill Efficacy: The hands were examined in seven areas as palm, back of the hand, between the fingers, specifically the thumb, fingertips, nails, anterior side of the wrist, posterior side of the wrist. Under the UV light, dirty spots were marked separately for right and left hands. The dirty spot was calculated as 1 point, and the clean spot was calculated as 0 points and 0 - 3-point range was considered clean; 4 - 7 point range was considered dirty (Škodová et al., 2015).

Hand Hygiene Assessment Question Form in School Children: The form used to question the hand hygiene behaviors of students was created in line with the "hand hygiene and hospital infections questionnaire for health professionals" developed by Tai et al. (2009) based on planned behavior theory components and was adapted to Turkish and age groups for primary school. The question form consists of 20 questions and 5 sub-dimensions: perceived behavioral control, subjective norm, attitude for hand hygiene, intention, and behavior. The Likert options of the questions differ and are scored between 0 - 4. The score of the sub-dimensions is obtained by summing the scores of questions in a section and dividing them by the number of questions answered by the student in that section. No total score is calculated for the overall form. The lowest score obtainable from each section is 0 and the highest score is 4. The content validity and reliability of the question form were tested by Uyanık and Dağhan in 2022. The content validity index is 1. The Cronbach α internal consistency coefficient was found to be 0.853 for the overall question form (20 questions) (Uyanık & Dağhan, 2022).

Ethical Consideration

Before starting the study, ethical permission for the research was acquired from the Committee on Clinical Research Ethics at Uludağ University Medical Faculty (Date: 11.01.2023, No: 2023-1/46). Institutional permission (No: E-94060517-604.02-70406724) was obtained from the Provincial Directorate of Education for the school where the study was conducted. Both students and parents or caregivers through the school administration before they were enrolled in the study informed written consent was acquired in an active manner. Permission was obtained from the authors of the scales.

Data Collection

Prior to the study, all school children and their parents were made aware of the study's objectives. During the pretest phase, all participants were instructed to wash their hands under the supervision of the researchers, look at their hands under UVA light after hand washing, and then fill out the HHAQSC. The hand washing phase of the study was conducted in the school laboratory. Priory, paper towels and soap were placed close to the sinks. Students were taken to the laboratory one by one. One month after the completion of the pretest phase, hand hygiene training was given. The first training session was given face-to-face by the researchers via PowerPoint presentation and a question-answer session. The training content included the definition of infections, the physiological structure of the hands (bacterial colonization on the normal skin, permanent

flora, temporary flora), hand washing methods (social hand washing, hygienic hand washing, hand disinfection), approaches for improving hand hygiene compliance, and infectious diseases due to hand hygiene noncompliance. The second training session was given online fifteen days after the first training session. The HH Training presentation for primary school students was distributed digitally to all participants, their parents, and schoolteachers. One month after the repetitive training sessions, the posttest phase was initiated. All applications in the pretest phase were repeated.

Intervention Group: Before hand washing, the participants were given four ml of Dermalux Test Lotion containing fluorescent that is detectable under UVA light. Students were asked to rub this lotion all over their hands. This lotion has a CE certificate. The company has declared in writing that the lotion does not contain any chemical components harmful to health in primary and kindergarten children. During data collection, four ml of neutral soap of the same brand, which does not have antimicrobial properties, was used. All psychomotor skills were marked on the HWSC throughout the hand washing process. The duration of hand washing (time from the start command in front of the sink to drying) was recorded with a mobile stopwatch. Then, washed hands were dried with a disposable towel paper and placed in the Derma Litecheck device in a dark environment. Hand washing effectiveness was evaluated using this device. The device shows dirty areas on the hand in a light color via UVA rays. Clean and dirty areas were recorded in HWSE by researchers. The students in this group were informed about which parts of their hands they could wash effectively by showing them on their hands.

Control Group: All steps were repeated. The students were not allowed to see their hands by wearing a black eye patch after the Derma Litecheck device intervention and no explanation was made. After the research was completed, to ensure equal opportunity in education, the UVA rays were repeated in the control group participants who were voluntarily under the supervision of the researchers.

Data Analysis

For continuous variables, baseline participant characteristics are given as mean ± standard deviation; for categorical variables, they are presented as frequency and percentages. The normality of each variable was verified using the Kolmogorov-Smirnov test. Chi-square, Wilcoxon, and Mann Whitney U analysis were performed for the significance of the scores. The difference between groups was compared on the basis of percentage change in repeated measures analysis (last measurement-first measurement / first measurement). All analyses were performed using SPSS 28.0 software for Windows. In the evaluation of the data, statistical analyses were accepted at a significance level of $p < 0.05$ with a 95% confidence interval.

Results

The demographic details of the students who took part in the study are shown in Table 1. The mean age of the participants was 8.68 ± 0.90. 54.3% of the participants in the intervention group and 48.6% of the participants in the control group were female. Regarding demographics, there was no difference between the groups ($p > 0.05$). Of the participants in the control group, 60% stated that they needed hand hygiene training. Of the participants, 90% stated that they did not receive training on hand hygiene at school; 71.4% did not know whether hand washing with soap prevents respiratory diseases; 50% did not know the efficiency of soapy hand washing in avoiding infectious diseases; 82.9% stated that soap cleans microbes in hand washing (Table 1).

Table 2 displays the intra-group comparison of hand washing effectiveness score distributions by area before and after the training. After the training for both hands, the intervention group students created a difference in the effectiveness of hand washing from dirty to clean in all areas, including the back of the hand, inside of the palm, between the fingers, fingertips, nails, thumb, and wrist ($p < 0.001$). The control group students created a difference in hand washing effectiveness by washing their nails more carefully after the training for the right hand ($p < 0.001$). However, there was no difference in the control group after the training in terms of effective hand washing in any area on the left hand ($p > 0.05$) (Table 2).

Table 3 shows the intra-group comparisons of the distribution of hand washing psychomotor skill scores of the participants before and after the training. Participants in the intervention group showed a difference of 11 steps from the first follow-up to the final follow-up, while the control group showed a difference of 3 steps.

Table 4 shows the inter- and intra-group comparison of the amount of time spent cleaning hands and washing score distributions of the participants before and after the training. The mean duration of hand washing of all participants in both groups showed an increase and a significant difference from the first to the final follow-up ($p < 0.001$). There was no difference between the groups in terms of the mean duration of hand washing before the training ($p > 0.05$) but there was a difference after the training ($p < 0.001$). The percentage change in the duration of hand washing was 0.19 - 3.62 in the intervention group and 0.47 - 1.35 in the control group, and there was a significant difference between the groups ($p < 0.001$). When the percentage change in the duration of hand washing score was compared between the first and final follow-up, the intervention group increased to 89 whereas the control group increased to 20 (Table 4).

Table 5 shows the intra-group comparison of the distribution of the participants' scores on the HHAQSC before and after the training. After the training, the students in the experimental group created a significant difference in sub-dimensions including the evaluation of their hand washing performance and the effectiveness of cleaning their hands (attitude for hand hygiene), the evaluation of the level of difficulty of hand washing (perceived, behavioral control), the intention for hand washing (intention), and the hand washing behavior (behavior) ($p < 0.05$). However, there was no difference in how much adults such as parents wanted the student to wash his/her hands (subjective norms) ($p > 0.05$). On the other hand, the control group students showed a difference only in terms of hand washing behavior compared to the pre-training ($p < 0.05$) (Table 5). There was no difference in other sub-dimensions compared to the pre-training ($p > 0.05$).

Discussion

In the current study, the effect of training given with the visual concretization method on the development of effective abilities to wash hands in students in primary school were inspected.

Table 1: Demographic Characteristics of Participants (n = 70)

Characteristic	With fluorescent concretization group (n = 35)		Without fluorescent concretization group (n = 35)		Total		Test Statistic†	p
	n	%	n	%	n	%		
Gender								
Female	19	54.3	17	48.6	36	51.4	1.356	0.076
Male	16	45.7	18	51.4	34	48.6		
Do you need education on hand hygiene?								
Yes	16	45.7	21	60.0	32	45.7	0.335	0.980
No	19	54.3	14	40.0	38	54.3		
Have you received education on hand hygiene at school?								
Yes	2	5.7	5	14.3	7	10.0	3.789	0.156
No	33	94.3	30	85.7	63	90.0		
Can washing your hands with soap prevent infectious diseases?								
Yes	7	20.0	6	17.1	13	18.6		
No	4	11.4	3	8.6	7	10.0	0.678	0.246
I don't know	24	68.6	26	74.3	50	71.4		
Can washing hands with soap prevent the transmission of diseases between people?								
Yes	13	37.1	12	34.3	25	35.7		
No	6	17.1	4	11.4	10	14.3	1.712	0.265
I don't know	16	45.7	19	54.3	35	50.0		
Is soap necessary, not just water, for the complete removal of germs?								
Yes	28	80.0	30	85.7	58	82.9		
No	2	5.7	2	5.7	4	5.7	0.598	0.279
I don't know	5	14.3	3	8.6	8	11.4		

n: Number; %: Percentage; †: Chi Square Test.

Table 2: Comparison of Students' Hand Washing Skill Efficacy Before, and After Training Period (n = 70)

Variables	With fluorescent concretization group (n = 35)				Without fluorescent concretization group (n = 35)			
Regions of evaluated right hand	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p
Back of the hand	0.71 ± 0.07	0.14 ± 0.35	-4.082	0.001*	0.65 ± 0.48	0.63 ± 0.47	0.000	1.000
Inside of the palm	0.82 ± 0.45	0.28 ± 0.45	-4.146	0.001*	0.60 ± 0.49	0.65 ± 0.48	-0.577	0.564
Between the fingers	0.85 ± 0.35	0.08 ± 0.28	-5.014	0.001*	0.80 ± 0.40	0.79 ± 0.38	0.000	1.000
Fingertips	0.85 ± 0.35	0.02 ± 0.16	-5.209	0.001*	0.97 ± 0.16	0.82 ± 0.38	-1.890	0.059
Nails	0.94 ± 0.23	0.08 ± 0.28	-5.477	0.001*	0.82 ± 0.38	0.71 ± 0.45	-3.162	0.002*
Thumb	0.68 ± 0.47	0.17 ± 0.38	-3.674	0.001*	0.68 ± 0.47	0.71 ± 0.45	-0.577	0.564
Wrist	0.57 ± 0.50	0.17 ± 0.38	-3.300	0.001*	0.68 ± 0.47	0.65 ± 0.48	-0.333	0.739
Regions of evaluated left hand	**First hand washing Mean ± SD**	**Final hand washing Mean ± SD**	**Test Statistic§**	**p**	**First hand washing Mean ± SD**	**Final hand washing Mean ± SD**	**Test Statistic§**	**p**
Back of the hand	0.71 ± 0.45	0.11 ± 0.32	-4.583	0.001*	0.74 ± 0.44	0.60 ± 0.49	-1.508	0.132
Inside of the palm	0.65 ± 0.48	0.14 ± 0.35	-4.025	0.001*	0.48 ± 0.50	0.62 ± 0.49	-1.667	0.096
Between the fingers	0.85 ± 0.35	0.02 ± 0.16	-5.385	0.001*	0.74 ± 0.44	0.80 ± 0.40	-0.816	0.414
Fingertips	0.88 ± 0.32	0.56 ± 0.46	-5.568	0.001*	0.94 ± 0.23	0.85 ± 0.35	-1.134	0.257
Nails	0.97 ± 0.16	0.05 ± 0.23	-5.657	0.001*	0.91 ± 0.28	0.88 ± 0.32	-0.378	0.705
Thumb	0.65 ± 0.48	0.05 ± 0.23	-4.379	0.001*	0.65 ± 0.48	0.71 ± 0.45	-1.000	0.317
Wrist	0.48 ± 0.50	0.08 ± 0.28	-3.300	0.001*	0.62 ± 0.49	0.77 ± 0.42	-1.508	0.132

†Comparison pretest and posttest between experimental group * $p < 0.05$; ‡Comparison pretest and posttest between control group * $p < 0.05$; §: Wilcoxon Signed Rank Test.

Feedback is an efficient approach to improve HH, according to Diefenbacher et al. (2019). Most children associate visible pollution on their hands with microbes but cannot associate invisible pollution with unsanitary conditions. Similarly, it has been observed in the literature that the use of visual concretization in training improves hand hygiene by emphasizing invisible microbes, increases hand hygiene compliance with an easy application, attracts students' attention, and encourages students to actively participate in the training (Skodov´a et al., 2015; Öncü et al., 2019; Kısacık, Ciğerci & Güneş, 2021). In the present study, fluorescent residues were observed in all participants' hands, between the fingertips, thumbs, and wrists at the first follow-up. At the end of the second follow-up, the fingertips, thumbs, and nails of the participants in the intervention group were the areas that were washed most effectively and carefully. On the contrary, the right-hand nails of the control group were the most effective and carefully washed area. Likewise, in another study, areas between the fingers and nails were the most common areas that were not rubbed (Skodov´a et al., 2015). When areas that were the most frequently forgotten during hand washing were evaluated, the areas that children skipped the most were fingertips and thumbs. In another study conducted with children aged 8 - 11, it was determined that the most frequently skipped areas during hand washing were the palms, dorsal metacarpal area, and fingertips (Öncü et al., 2021). In another study conducted with an adult population in Hong Kong, the most frequently skipped areas during hand washing were reported as the fingertips (48.1%), the medial area (30.5%), the back of the hand (28%), and the palm (22.1%) (Wong & Lee, 2019). When HH is not adequate, pathogens remaining on children's hands can act as a reservoir, and squeezing fingers and palms can result in order to sanitize these places more successfully, as outlined in the phase model of WHO. In our study findings, it was seen that the dorsal surfaces were cleaned more effectively compared to the palm surfaces. Contrary to our findings, in a study conducted in Taiwan, it was found that skipped areas in the dorsal area of health professionals were more compared to the palm (Pan et al., 2014). This different result may be due to the fact that the process step "立" (put your fingertips on the palm of the other hand) process step, which is a Chinese cultural slogan, is reinforced everywhere both visually and in writing.

In studies conducted to examine hand hygiene behaviors, it has been revealed that children's education should be re-organized to improve their psychomotor skills during hand washing (Loschiavo, 2015). In previous studies, it has been also indicated that visually learning students can develop effective hand washing techniques when hand hygiene training is visually adapted (Morton & Schultz, 2004). Some examples supporting this view are available in the literature (Snow, White & Kim, 2008; Fishbein, Tellez, Lin & Sullivan, 2011). In the present study, the most skipped steps during hand washing in both groups were found to be rubbing the thumbs by grabbing them into the hand (62.9%), rubbing the wrists (74.3%), taking the fingertips into the hand (67.1%), and rinsing the tap with some water (81.4%). In another study conducted with primary school children, it was found that similar steps such as rubbing the thumbs by grabbing them in the hand (69.2%), rubbing the wrists (50.4%), putting the fingertips into the hand (70.8%), and using soap to completely foam your hands (69.4%) were skipped (Ozcan et al., 2020). The results of the current study's first follow-up on hand washing psychomotor skills revealed that schoolchildren in both the intervention and the control groups were unable to practice this fundamental skill in an efficient manner. The findings revealed that the visual feedback with explanation in the intervention group significantly improved the final hand washing psychomotor skills and caused a significant difference between the groups with a strong effect on skill scores. These findings showed that the visual feedback provided by applying UVA increased the hand washing psychomotor skills of the students and positively affected their awareness of previously neglected areas during hand washing. The results of the study, in which visual feedback was given using fluorescent lotion, support that it can be a useful option for improving students' HH compliance and psychomotor skills (Fishbein et al., 2011; Suen, Wong, Lo & Lai, 2019). Furthermore, the lack of sufficient improvement in the total hand washing psychomotor skill scores of the participants in the control group supports that conventional methods of instruction are ineffective in developing such skills and maintaining the desired behavior.

The Ministry of Health in Turkiye recommends practicing correct hand washing as organizations such as CDC in the USA, the Public Health Agency in Canada, National Health Service in the UK, Centers for Health Protection in Hong Kong, and the Global hand washing Partnership, which emphasizes the importance of hand washing. This practice includes hand washing with soap and water before and after at least eight specific situations. The process consists of twelve steps in seven areas of both hands and should last at least 20 seconds (Bilici & Buzgan, 2008).

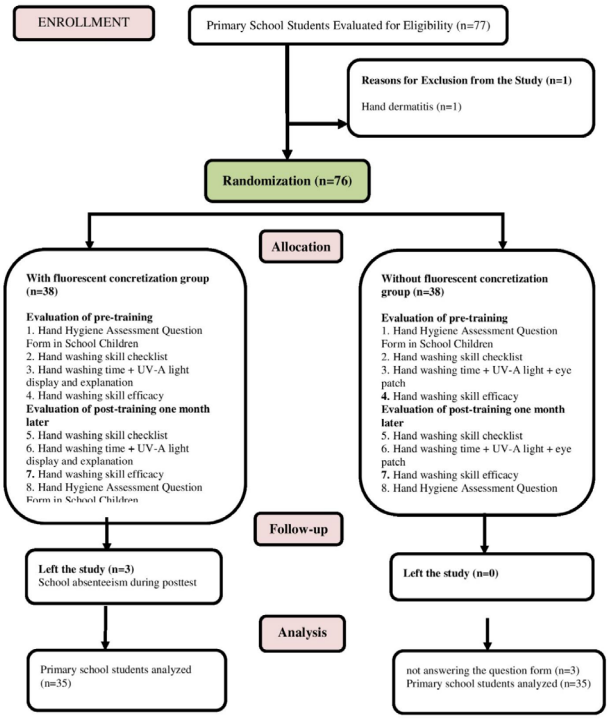

Figure 1: Study flow chart (CONSORT diagram)

Table 3: Comparison of Students' Hand Washing Skill Checklist Before and After Training Period (n = 70)

Implementation Steps	With fluorescent concretization group (n = 35)				Without fluorescent concretization group (n = 35)			
	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p
Pull up your sleeves	1.02 ± 1.01	1.88 ± 0.40	-3.819	0.001*	1.11 ± 0.99	1.68 ± 0.71	-2.500	0.012*
Wet hands with some water	1.22 ± 0.94	1.65 ± 0.68	-1.915	0.056	1.42 ± 0.77	1.62 ± 0.78	-1.204	0.229
Turn off the tap	0.88 ± 0.93	1.60 ± 0.73	-3.031	0.002*	0.85 ± 0.84	1.11 ± 0.96	-1.572	0.116
Take some liquid soap in your hands	1.14 ± 0.97	1.74 ± 0.61	-3.181	0.001*	1.14 ± 0.94	1.22 ± 0.94	-0.485	0.628
Foam your hands thoroughly with a little soap	1.37 ± 0.80	1.74 ± 0.56	-1.911	0.056	1.42 ± 0.65	1.17 ± 0.89	-1.857	0.063
Rub between the fingers by clasping hands	1.17 ± 0.92	1.80 ± 0.47	-2.996	0.003*	1.14 ± 0.94	1.20 ± 0.93	-0.187	0.851
Scrub by taking the thumb fingers into your hand	0.68 ± 0.90	1.94 ± 0.23	-4.625	0.001*	0.54 ± 0.81	0.62 ± 0.84	-0.640	0.522
Rub the back of the hand	1.02 ± 0.98	1.97 ± 0.16	-4.032	0.001*	0.74 ± 0.81	1.20 ± 0.93	-1.875	0.061
Rub your wrists	0.42 ± 0.77	1.60 ± 0.69	-4.540	0.001*	0.48 ± 0.85	0.82 ± 0.92	-1.872	0.061
Scrub with fingertips in hand	0.77 ± 0.94	1.85 ± 0.49	-4.291	0.001*	0.37 ± 0.73	0.46 ± 0.93	-3.287	0.001*
Rinse hands thoroughly	1.57 ± 0.77	1.88 ± 0.32	-2.194	0.020*	1.40 ± 0.73	1.02 ± 0.98	-1.886	0.059
Rinse the tap with some water	0.45 ± 0.81	1.17 ± 0.92	-3.233	0.001*	0.20 ± 0.58	0.94 ± 0.90	-3.065	0.002*
Dry hands thoroughly, including between the fingers	1.14 ± 0.69	1.80 ± 0.58	-3.734	0.001*	1.37 ± 0.77	1.57 ± 0.77	-1.133	0.257
Throw the towel away	1.80 ± 0.58	1.94 ± 0.23	-1.394	0.163	1.82 ± 0.51	1.60 ± 0.73	-1.554	0.120

†Comparison pretest and posttest between intervention group * p < 0.05; ‡Comparison pretest and posttest between control group * p < 0.05; §: Wilcoxon Signed Rank Test.

Table 4: Comparison of Participants' Hand Hygiene Assessment Question Form in Schoolchildren Before, and After Training Period (n = 70)

Variables	With fluorescent concretization group (n=35)				Without fluorescent concretization group (n=35)			
	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p	First hand washing Mean ± SD	Final hand washing Mean ± SD	Test Statistic§	p
Attitude for hand hygiene	3.42 ± 0.49	3.76 ± 0.37	-3.148	0.002*	3.28 ± 0.58	3.30 ± 0.73	-0.710	0.478
Perceived behavioral control	3.17 ± 0.69	3.68 ± 0.40	-3.617	0.001*	3.29 ± 0.64	3.25 ± 0.82	-0.259	0.796
Subjective norm	3.39 ± 0.62	3.60 ± 0.50	-1.875	0.061	3.11 ± 0.78	3.13 ± 1.04	-0.173	0.863
Intention	3.23 ± 0.59	3.54 ± 0.47	-2.909	0.004*	3.17 ± 0.66	3.19 ± 0.83	-0.104	0.917
Behavior	3.00 ± 0.79	3.42 ± 0.65	-2.338	0.019*	2.93 ± 0.95	3.36 ± 0.98	-2.341	0.019*

†Comparison pretest and posttest between intervention group * p < 0.05; ‡Comparison pretest and posttest between control group * p < 0.05; §: Wilcoxon Signed Rank Test.

The time allocated for effective hand washing is very important. Although the European Center for Disease Prevention and Control has recommended washing hands for 30 seconds, some studies have shown that this time is insufficient for HH (Kampf, Reichel, Feil & Eggerstedt, 2008; Zingg, Haidegger & Pittet, 2016). Prior studies have demonstrated that the duration of hand scrubbing is significantly associated with the number of bacteria on the hands (Ibeneme et al., 2017; Mumma et al., 2019). In the current study, the fact that the mean duration of hand washing of the participants in the intervention group and the difference in the HWSC percentage change once again emphasized the importance of duration. In this study, the median value of the duration of hand washing among participants was determined as 33 seconds in the intervention group and 40 seconds in the control group before the training. One month after the training, the duration was determined as 64 seconds in the intervention group and 45 seconds in the control group. Likewise, Ozcan et al. (2020) found the median value of the amount of time spent washing hands among participants as 13 seconds before the training, 17 seconds after the training, and 20 seconds 1 month after the training. The amount of time spent washing hands increased after training. Current research findings show that "increased time allocated to hand washing" is important for effective hand washing in both technical and time-based aspects.

Within a cluster randomized controlled trial, in which the HHAQSC, which was developed according to the theory of planned behavior, was used with other psychosocial (Health Belief Model) and education (Bloom Taxonomy) theories to create the content of hand hygiene training, no significant difference was reported between the groups in terms of their attitudes, motivation, skills, normative beliefs, perceived sensitivity and perceived seriousness scores (Appiah-Brempong, Newton, Harris & Gulis, 2020). In the present study, no difference was determined between the subjective norm scores of the participants in the intervention group in the pre- and post-training comparison. In the control group, there was no difference between the attitude for HH, perceived behavioral control, subjective norm, and intention scores. The HH behavior scores increased in both groups and a significant difference was found between the groups in the posttest. The difference in study results between this study and the study of Appiah-Brempong et al. (2020) may be since the question form was based on participants' self-reports. In the theory of planned behavior, knowledge is one of the premises of the beliefs (behavioral belief, normative belief, control beliefs) which are the determinants of behavior (Fishbein & Ajzen, 2009).

Study Limitations

There were limitations on this investigation. First, it was a single-centre study; therefore, the results may not be generalizable to other primary schools with different characteristics. Second, it was assumed in this study that areas covered with fluorescent material on hands after washing could represent residual pathogens in the assessment of the efficacy of students' HH abilities. The limitations of this study were the lack of rating the images that were acquired with the hand scanner and the fact that the areas covered with fluorescent were not examined under UVA before washing.

Conclusion

In conclusion, visual concretization and explanation were given to the participants in the intervention group, which statistically differs in the hand-washing effectiveness in all areas for both the right and left hands compared to the control group. In the control group, hand washing was effective enough to make a difference only in the right-hand nails, and no difference was found in all other areas of both hands. Psychomotor skill and duration of hand washing scores increased in all groups and the percentage change in the total score increased more in the intervention group participants' when the first and the final follow-up were compared. In the posttest of the question form, the knowledge of the participants in both groups about the cases in which hand washing was necessary increased. It is crucial in this particular study to provide training to school children with visual feedback so that they can accurately evaluate the effectiveness of their HH behaviors and efforts. The use of technologies that generate tangible data will facilitate the HH compliance process in acquiring permanent behavior. For this reason, it is highly recommended that visual devices that provide feedback be used in school children's education.

Ethical Considerations: Ethical approval was obtained from the Ethics Committee of Bursa Uludağ University Medical Faculty for this study (Date: 11.01.2023 and No: 2023-1/46).

Author Contribution: Study Idea (Concept) and Design – HY, CYK; Data Collection / Literature Review – CYK; Analysis and Interpretation of Data – HY, CYK; Preparation of the Article – HY, CYK; Approval of the Final Version to be Published – HY, CYK.

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