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Human Stimulation Threshold of Interferential Current Type Low Frequency Stimulator for Electric Shock Experience Education

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전기 감전 체험 교육을 위한 저주파 전류 자극기의 인체 자극 임계값

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Abstract To prevent electric shock accidents, an experience education is more effective than indoctrination education. But an electric shock experience education system required a proper physical stimulation on human body to experience electric shock. This paper experiment threshold values of a human body by using Interferential Current Type Low Frequency Stimulator in order to apply to an electric shock experience education system. And the proper stimulation values are calculated according to age (divided child and adult) and gender. Results of this study could be applied to an electric shock experience education system.

요 약 전기감전 사고를 예방하기 위해서는 주입식 교육 보다는 체험식 교육이 더욱 효과적이다. 그러나 전기감전 체험형 교육 시스템을 위해서는 감전을 체험할 수 있도록 인체에 대한 적절한 물리적 자극이 필요하다. 본 논문에서는 간섭전류형자극기(Interferential Current Type Low Frequency Stimulator)를 감전사고 체험교육에 이용하기 위하여 인체에 대한 자극의 임계값을 실험하였다. 그리고 아동과 성인으로 구분된 연령별 자극 값을 산출하였다. 본 연구의 결과는 전기 감전 체험형 교육 시스템에 적용 가능할 것이다.

Key Words : Electric shock, accident, Experience, education, Stimulation

1. Introduction

In spite of a wide variety of activities to prevent electrical safety accidents, electric shock accidents had not decreased in Korea as shown in table 1 [1, 2]. The most of electrical safety accidents happen because of human error. In order to prevent these accidents by human error, a systematic and long-term education is required. It is very important that people are aware of electrical hazards and the proper preventative actions including education to reduce electrical shock [3].

[Table 1] Electric shock accident statistics for the recent three years in Korea.

Year	Death	Injury	Sum
2008	68	497	565
2009	46	533	579
2010	46	535	581

So far, education to prevent electrical safety accidents was indoctrination using text and image. Since the passive methods of education that are currently used by using audio-visual education are not the most effective. It is

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unsuitable except adult who concern about electrical safety. Especially, introduction of various education method for child and infants who concentration and understanding are lack than adult is needed.

The advancement of virtual reality (VR) technology and medical device enable to develop a system to experience electric fire and electric shock. An experience education system to prevent electrical safety accidents, which must use the proper stimulation values on a human body to experience electric shock accident.

In this paper, Interferential Current Type Low Frequency Stimulator was considered as the method to experience electric shock. Generally, Physiological therapy using Interferential Current Stimulator (IFS) has been in use for many years and its effectiveness is well documented. The basic principle of IF) is to utilize the strong physiological effects of the low frequency electrical stimulation of muscle and nerve tissues at sufficient depth, without the associated painful and somewhat unpleasant side effects of such stimulation.

Although IFS is useful for experiencing electric shock in the electrical safety education system, there are many problems that must be considered. If stimulation on a human body is too strong to heighten learning effect, motive level could fall down because displeasure or trauma in severe cases can happen.

On the other hand, if stimulation is too weak, there is no learning effect because arousal status to detect danger of electric shock can be dropped. But there is no literature on the intensity of stimulation according to age, gender, education content and so on.

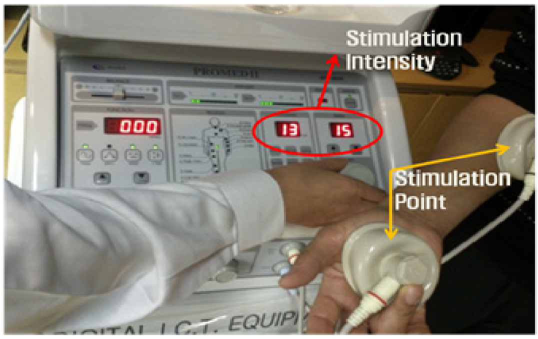
Therefore, in order to maximize learning effect, it is need to determine threshold values of electric shock stimulation according to age, gender and experience education contents. This paper calculated threshold values of a human body according age and gender in using Interferential Current Type Low Frequency Stimulator in order to apply to an electric shock experience education system.

2. Method

Interferential Current Type Low Frequency Stimulator STI-300, which can adjust current stimulation from 1 mA to 50mA, was used to calculate electric stimulation values on the human body that can be applied to an electric shock experience system.

66 healthy volunteers participated in the experiment. They consist of 38 male (child 11, adult 27) and 28 female (child 13, adult 15). Before the experiment, data to have an influence on current stimulation values like as height, weight, age and gender was collected. Interferential currents two independent kilohertz frequency alternated currents (ACs) of constant intensity that are applied by two pairs of electrodes placed diagonally.

The interference of the two ACs at the intersectional area produces sinusoidal current modulation at a frequency equal to the difference between the two ACs [4-8]. 3～20mA current stimulation provided in right palm and the forearm (adult 12 cm and child 10 cm) for 4 seconds in order to remove tiredness effect as shown in Fig. 1 and 2. And self-report 5-point scale about displeasure, awakedness and pain was reported by experiment participants.



[Fig. 1] Stimulation point and intensity control

[Fig. 2] Test scene using Low Frequency Stimulator STI-300

3. Experimental Result

Table 2 shows the mean, maximum and The mean intensity was 14mA and mean of displeasure, pain and arousal was under minimum intensity of Interferential Current (IFC) stimulation of total 66 experiment participants. The mean intensity was 14mA and mean of displeasure, pain and arousal was under 3-level (normal level). And there is no pain, inconvenience and displeasure in experiment.

Table 3 shows experiment results according to gender (male and female) and age (child and adult). In case of child, there is no gender difference but In case of adult, there is the male and female interaction.

But displeasure, arousal and pain on mean stimulation are low and if stimulation exceeds the maximum value, it is expected that there is an adverse effect of education because of big pain on stimulation. And maximum stimulation values according to age and gender didn't result in maximum value of arousal because of displeasure and pain as shown in table 3 and 4.

Therefore, the criteria for selecting stimulation current depending on whether education system has a powerful penalty-based contents or compensation-based contents and can be made as follows:

- · Case of a powerful penalty-based education system: Maximum stimulation current (mA) that body side effect can be minimized.
- · Case of a compensation-based education system: Stimulation current (mA) that which negative is minimum and arousal is maximum

[Table 2] Mean, Maximum (max), and Minimum (min) stimulation current of experiment participants

	Height [cm]	Weight [kg]	Current [mA]	Displeasure Mean	Pain Mean	Arousal Mean
Mean	164.00	56.92	14.30	2.68	2.67	2.63
max	189	85	20	3.83	4.00	4.19
min	104	18	8	1	1	1

[Table 3] Mean, Maximum (max), and Minimum (min) stimulation current according to age and gender.

Male child	**Height [cm]**	**Weight [kg]**	**Current [mA]**	**Displeasure Mean**	**Pain Mean**	**Arousal Mean**
Mean	148.91	42.64	8.91	1.90	2.18	1.87
Max	171.00	63.00	10.00	3.00	3.00	3.00
Min	104.00	18.00	8.00	1.00	1.29	1.00
Male adult	**Height [cm]**	**Weight [kg]**	**Current [mA]**	**Displeasure Mean**	**Pain Mean**	**Arousal Mean**
Mean	177.04	71.89	18.26	2.91	2.76	2.91
Max	189.00	85.00	20.00	3.64	3.61	3.78
Min	168.00	58.00	12.00	1.39	1.56	1.00
Female child	**Height [cm]**	**Weight [kg]**	**Current [mA]**	**Displeasure Mean**	**Pain Mean**	**Arousal Mean**
Mean	151.00	41.92	8.92	2.24	2.36	1.88
Max	165.00	58.00	10.00	3.83	3.50	3.29
Min	122.00	22.00	8.00	1.00	1.00	1.00
Female adult	**Height [cm]**	**Weight [kg]**	**Current [mA]**	**Displeasure Mean**	**Pain Mean**	**Arousal Mean**
Mean	162.87	53.47	15.80	3.24	3.16	3.32
Max	174.00	59.00	20.00	3.81	4.00	4.19
Min	155.00	45.00	9.00	2.00	2.38	1.85

[Table 4] Stimulation current and education effect

Male child	Max arousal, Min Current[mA]	Negative-Max arousal	The most negative stimulus
Mean	8.00	3.57	3.71
Max	9.00	5.00	5.00
Min	6.00	1.50	1.50
Male adult	**Max arousal, Min Current[mA]**	**Negative-Max arousal**	**The most negative stimulus**
Mean	13.78	4.42	4.86
Max	19.00	5.00	5.00
Min	7.00	2.50	3.50
Female child	**Max arousal, Min Current[mA]**	**Negative-Max arousal**	**The most negative stimulus**
Mean	7.63	3.44	4.19
Max	9.00	5.00	5.00
Min	6.00	2.00	3.00
Female adult	**Max arousal, Min Current[mA]**	**Negative-Max arousal**	**The most negative stimulus**
Mean	11.77	4.54	4.92
Max	18.00	5.00	5.00
Min	8.00	3.50	4.00

4. Discussion and conclusion

In this paper, stimulation of IFC applied to human body was gradually increased. Also, in case that critical pain and displeasure of participants by large stimulation current was reported, the intensity of stimulation was adjusted to smaller level than the intensity which they can endure because of dangerousness of human body and psychological Trauma. And, in case of child, the reliability problem of the self-report 5-point scale by child’s uncertain concept about displeasure, pain and arousal was minimized by securing statistically stable participants.

This paper calculated threshold values of a human body by using Interferential Current Type Low Frequency Stimulator in order to apply to an electric shock experience education system. And the proper stimulation values are calculated according to age (divided child and adult) and gender. In future, results of this study could be applied to the determination of the proper stimulation values of an electric shock experience education system according to a variable such as electric shock education contents and age, gender, weight and height of user.

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