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Evaluation of the grip strength of Korean female hair designers and the usability of a smart IoT grip strength measuring device

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Abstract

In this study, we compared the grip strength of female hair designers and female college students using a smart IoT grip strength measuring device and conducted a usability evaluation of the smart IoT grip strength measuring device. The subjects of the study were 30 female hair designers and 27 female college students in their 20s. Of these, 23 participated in the user evaluation. The maximum grip strength of the right and left hands was measured using a smart IoT grip strength measuring device (Soundbody, Korea). The user evaluation consisted of a total of 3 questions on a 5-point scale, including ease of installation of the IoT device, satisfaction with the user interface and interaction with the IoT device, and evaluation of the reliability and performance of the IoT device. As a result of the study, user evaluations of smart IoT grippers showed some dissatisfaction with the ease of installation of smart devices. Still, many positive responses were received regarding the user interface, interaction, reliability, and performance. In this study, the grip strength of the right hand was higher than that of the left hand of the subjects, and the grip strength of hair designers was lower than that of female college students. There was no difference in the right hand of hair designers compared to college students, but the grip strength of the left hand decreased by 66.3%. Frequent upper extremity workers with low loads appear to have low grip strength.

Keywords: Female, Grip strength, Hair designer, Smart IoT grip strength, Usability.

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1. Introduction

The advent of digital technology, known as wireless communication and the Internet, has brought revolutionary changes to all areas of society. With the launch of computer-based mobile phones (smartphones) in 2007, smartphones have become an essential part of daily life in all societies [1, 2]. Over the past decade, smartphone ownership and use have grown exponentially worldwide, with 35% of adults in the US and 39% in the UK using a smartphone in 2011 and 2012, respectively. In 2017, there were approximately 2.1 billion people, and the number is expected to exceed 2.8 billion worldwide by 2020 [2].

The development of various functions and performances of these smartphones is attracting increasing interest from academics and clinicians in using them to mediate or measure health behaviors. Smartphones have the advantage of being portable and allowing people to intervene in real-life situations. Applications (apps) on smartphones can provide affordable, convenient, and less stigmatizing interventions, and the connectivity of smartphones facilitates the sharing of behavioral and health data with professionals or colleagues [3]. Smartphone software programs or applications have significantly advanced in recent years [2]. Thousands of commercial apps are already available to improve and manage people's health, and there is a growing need for more accurate and integrated measurement tools for these apps [4].

Measurement of grip strength using a smartphone application has the advantage of being easy and useful in everyday life. Grip strength is a representative indicator of muscle strength and is a very efficient indicator that can evaluate the current overall strength level and muscle mass [5]. A cross-sectional study utilizing National Health and Nutrition Examination Survey (NHANES) data (4,524 participants) also identified a significant negative relationship between hand grip strength and heart failure, which persisted consistently even after adjusting for various covariates such as age, gender, race, income, education, body mass index, smoking and drinking status, diabetes, hypertension, stroke, physical activity level, and dietary intake. These findings suggest that a decline in muscle function in adults over 45 could be associated with the development of heart failure, indicating that enhancing muscle strength could play a crucial role in strategies for preventing and managing heart failure [6].

Thus, advancements in measurement technologies can potentially improve patient care and rehabilitation outcomes through enhanced data collection and analysis capabilities. Measuring muscle strength through grip strength is evaluated as a useful method that is non-invasive, simple, and convenient for measurement [5]. Muscle strength is used as an important health indicator not only for the healthy population but also for individuals suffering from various diseases. Suppose you expand the measurement of grip strength through a smartphone application and basic biometric indicators such as breathing, pulse, and body temperature. In that case, it will be efficiently utilized for personal health management.

Hand grip strength varies depending on gender [7], and hand grip strength changes depending on the load of work performed on the hands of female workers and the length of time the load is applied [8]. The upper limb strength of hair designer women whose work involves using the upper limbs may differ from that of general women or office workers due to the nature of their occupation. As income levels rise and living standards improve due to economic growth and industrial development, the desire for a humane life and beauty increases and the beauty industry expands as a market of important value [9]. Moreover, the role of modern beauty industry workers is expanding beyond simple customer service and the provision of technology to include professional customer service and marketing, as well as expertise in technology to express beauty and customer health management. Accordingly, segmentation and expertise by area are required in the scope and role of work [10].

2. Related Works or Literature Review

Based on the 2020 Economic Census registration, the total number of hair and beauty businesses is 170,488, and the number of employees is 218,210 as of 2020 [11]. A hair designer provides beauty services such as shampooing, haircuts, hair perms, hair coloring, scalp and hair care, hair styling, and makeup using beauty equipment and products to customers who want to increase emotional satisfaction and self-esteem by satisfying aesthetic needs [12].

According to the National Competency Standards (NCS), there are 41 competency units in the hair beauty field [12]. The most basic competency units that must be possessed to become a hair designer are the ability to use hair shampoo and treatment, the ability to dry, desk, and provide customer service, and hygiene management for hairdressers and establishments. Of the total 41 competency units, 20 are high competency units, indicating important units. A detailed look at the 20 competency units is as follows: the ability to use hair shampoo and hair treatment; hairdresser's personal hygiene; hygiene management at the beauty shop; the ability to prevent safety accidents in the beauty industry; the ability to straight dry and C-curl dry; the ability to prepare, manage, and complete scalp and hair care; the ability to conduct desk information; serve waiting customers, and see customers off; how to use professional hair care products and the ability to recommend products; the ability to finish with a roll hair perm; the ability to finish with a magic straight hair perm; the ability to finish by basic 45-degree, 90-degree, and 135-degree winding; the ability to finish with a one-length haircut; the ability to finish with a digital setting hair perm; the ability to collect, utilize, and manage customer information; the ability to finish with a graduation haircut; the ability to finish with basic hair color; the ability to finish with a volume magic hair perm; the ability to collect customer beauty service information to suggest styles and set rates; the ability to finish by vertical, block, or double winding; the ability to prepare, execute, and complete head spa care; the ability to use special purpose shampoos and special treatments; these include the ability to dry S curls and S-S curls [13]. As such, most of the work units of hair designers are dynamic and low-load tasks that require the use of the hands or upper extremities.

There are studies on job stress [14, 15] studies on musculoskeletal disorders targeting hair designers [16, 17], and studies on psychological characteristics such as job expertise and self-efficacy of hair designers [18-20]. There are no studies on grip strength or muscle strength. Research on this needs to be included. Accordingly, this study aims to compare the grip strength of female workers working in the hair design profession and female college students and conduct a usability evaluation of a grip strength measuring instrument using a smart IoT digital device. Through this, we would like to confirm the status of work-related muscle development and the usability of the smart IOT grip strength measuring device.

3. Research Method

This study's subjects were 57 women in their 20s, 30 female hair designers, and 27 female college students. Using Cohen's f in G*Power, the effect size for the ANOVA was set to 0.4, the significance level was 0.05, and the power was set to 0.95. The minimum sample size required for the one-way ANOVA was approximately 16 people for each group. Therefore, a sufficient sample size was met in this study.

This study was approved by the Sehan University Institutional Review Board (SH-IRBB 2024-007). The experimental methods and procedures were explained to all research subjects based on human subjects' research ethics, and the research subjects agreed to the experimental processes and procedures.

In one case, participation was voluntary. It was explained that participants could stop participating at any time during the experiment if they did not wish to continue. The selection criteria for the study subjects were adults without musculoskeletal diseases of the shoulder, arm, wrist, or fingers, and without neurological diseases, who agreed to participate in this study. People with cognitive function problems or diabetes were excluded.

4. Research Validation

4.1. Method of Grip Strength Measurement

This study measured the maximum grip strength of the right and left hands twice using a smart IoT grip strength measuring device (Soundbody, Korea). After the first measurement, the second measurement was taken after a one-minute rest. Before measuring grip strength, an explanation and demonstration were provided, and the subjects were asked to practice once to measure it naturally. Then, the measurement was conducted.

The Smart IoT Grip strength device (Figure 1) is a grip strength meter with proven reliability [21] that is linked to a smartphone app (sound body grip), and the level of grip strength and heart rate can be checked visually and numerically in the app.

The smart IoT grip strength meter is a multi-functional device that simultaneously measures the user's grip strength, pulse, and movement by connecting to an application using a combination of the smartphone's inertial sensor and force sensor. To check the screen of the smartphone with the smart IoT grip strength meter, the subjects sat down, wrapped their hands around the entire grip strength meter with their elbows slightly bent at about 20 to 30 degrees, and held the grip strength meter with maximum force for 3 seconds. The numbers appearing in the app were checked and recorded.

Figure 1.
Smart IoT grip strength measuring device (Soundbody, Korea).

4.2. User Evaluation

Usability evaluation refers to measuring the convenience of using a certain software or product. It considers the user's physical condition and usage environment and includes expert and user evaluation. Since remote evaluation is recommended to evaluate apps [22] the evaluation of apps connected to a smart IoT grip strength measuring device is included.

The user evaluation was conducted by 23 voluntarily participating study participants. The evaluation of users for smart IoT devices was conducted using an online survey form, and it was limited to three questions on a 5-point scale (very dissatisfied, dissatisfied, average, satisfied, and very satisfied). The user evaluation consisted of three questions: the setup and installation ease of the smart IoT device, satisfaction with the user interface and interaction with the smart IoT device, and the reliability and performance of the smart IoT device.

4.3. Data Analysis

The measured data were analyzed using the statistical program SPSS 26.0. Grip strength was measured twice and analyzed using the average value. Data on general characteristics and grip strength were subjected to descriptive statistics using average values.

Pearson correlation analysis was performed to determine the relationship between occupation and grip strength, and binomial logistic regression analysis was conducted to determine the effect of hairdresser occupation on grip strength. Frequency analysis was performed for user evaluation. The significance level was set at $p < .05$. In addition, a t-test was conducted to compare the mean grip strength between the two groups.

5. Results and Discussion

5.1. Age of Subjects

The ages of the study subjects are shown in Table 1 Although the female college students and the hair designer were in their 20s, they were older than the female college students.

Table 1.
Age of subjects.

	Job	N	Mean	SD
Age (years)	Female college student	27	20.04	.71
	Hair designer	30	23.63	2.77

5.2. Result of User Evaluation

Twenty-three people participated in the grip strength measurement and the user evaluation. According to user ratings, the average age of the participating subjects was 22.00 ± 1.98 years. Figure 2 shows the results of a smart IoT device usability satisfaction survey conducted in three aspects.

First (Q1), regarding the ease of setting up and installing smart IoT devices, 'average' and 'slightly dissatisfied' recorded the highest rates at 35%. Second (Q2), satisfaction with the user interface and interaction was in the order of 'average' (43%) and 'somewhat satisfied' (26%). Lastly (Q3), the highest level of satisfaction with the reliability and performance of smart IoT devices was 'somewhat satisfied' (39%), followed by 'average' (30%).

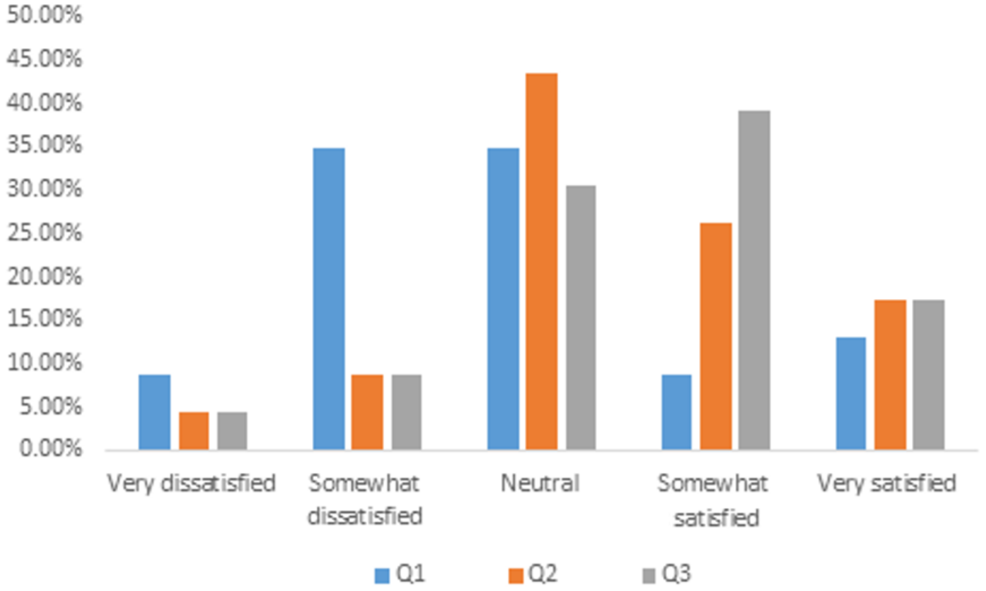

Figure 2.
Result of user evaluation.

5.3. Comparison of Left and Right Grip Strength

The grip strength of the study subjects' right and left hands was measured and compared, and the results are presented in Table 3.

When measured with a smart IoT grip strength meter, the woman's right-hand grip strength was 24.70 ± 6.34 kg, and her left-hand grip strength was 22.01 ± 5.54 kg, which was statistically significant (p < .001). Therefore, the grip strength of women's right and left hands appears to differ.

Table 2.
Comparison of left and right grip strength (n: 57, unit: Kg)..

	Mean	SD	t	p
Right hand	24.70	6.34	7.121	.0000
Left hand	22.01	5.54		

5.4. *Comparison of Grip Strength According to Job Characteristics*
A comparison of the grip strength of hair designers and female college students is presented in Table 3.

When the grip strength was measured with a smart IoT grip strength device, the right-hand grip strength of female college students was 29.61 ± 4.18 kg, while that of hair designers was 25.17 ± 3.32 kg, which was statistically significant (p<.001). The left-hand grip strength was 30.31 ± 2.67 kg for female college students and 25.70 ± 2.69 kg for hair designers, which was also statistically significant (p<.001). The grip strength of female hairdressers was lower than that of female college students.

Table 3.
Comparison analysis of grip strength between jobs (n: 57, unit: kg).

	Group	N	Mean	SD	t	p
Right hand	Female college student	27	29.61	4.18	4.416	0.000
	Hair designer	30	25.17	3.32		
Left hand	Female college student	27	30.31	2.67	6.499	0.000
	Hair designer	30	25.70	2.69		

5.5. Correlation Analysis between Occupation and Grip Strength

A correlation analysis was conducted between occupation and grip strength, and the results are presented in Table 4. A moderate negative correlation was found between occupation and right-hand grip strength (r = -0.564, p < 0.01).

A moderate negative correlation was found between occupation and left-hand grip strength (r = -0.595, p < 0.01). In other words, hand grip strength was lower for those working as hair designers than for female college students.

Table 4.
Correlation of grip strength and job (n = 57, unit = kg).

	Right hand	Left hand
Job	-0.564^{**}	-0.595^{**}

Note: **. p<0.01.

5.6. Analysis of the Influence of Hair Designer Occupation on Grip Strength

Binomial logistic regression analysis was conducted to determine the influence of hair designers and female college students on grip strength. The analysis results are presented in Table 5.

Right-hand grip strength was not statistically significant. Left-hand grip strength was found to have a statistically significant effect at the significance level of 0.05. As the hair designer's left-hand grip strength increases by 1, it increases by 0.663 times. Hair designers' left-hand grip strength decreased by 66.3% compared to college students. This suggests that although hair designers use their left hands a lot due to the nature of their jobs, their actual grip strength may be lower than that of college students due to repetitive tasks.

Table 5.
Correlation of Grip Strength and Job.

	B	SE	Wald	p	OR	95% CI	
						LLCI	ULCI
Right hand	-0.176	0.120	2.130	0.144	0.839	0.662	1.062
Left hand	-0.411	0.174	5.620	.018	0.663	0.472	0.931

5.7. Discussion

This study aimed to compare the grip strength of female hair designers and female college students and to conduct a usability evaluation of a grip strength measuring instrument using a smart IoT digital device.

In this study, the grip strength of the subject’s right hand was higher than that of their left hand, and hair designers had lower grip strength than female college students. The fact that the subjects' grip strength in this study was higher in their right hand than in their left hand is consistent with previous studies. In a study by Joung, et al. [9] and Lee and Roh [23] general adults' hand grip strength measurement results showed that right-handed people had stronger right-hand grip strength. Most

Koreans are right-handed, which makes them use their right hand more, naturally strengthening their right-hand grip strength. This can be attributed to the higher usage and, consequently, greater strengthening of the right hand in most right-handed individuals.

The result that hair designers had lower grip strength than female college students is interesting. Hair design requires repetitive and detailed hand movements but does not require much grip strength. Additionally, if these tasks are repeated, muscle fatigue may accumulate, and strength may decrease. Kourinka, et al. [24] stated that occupations such as hairdressers cause hand and wrist fatigue due to repetitive hand movements, which can have a negative impact on hand grip strength in the long term.

Han [25] investigated the areas where beauty industry workers suffer from pain and found that the pain rate was high in the shoulders, neck, waist, wrists, and upper arms. Therefore, judging from the results, most workers in the beauty industry suffer from musculoskeletal diseases in the shoulders, neck, and back due to the nature of their jobs.

Additionally, a study by Song and Han [16] showed that pain was felt in the following order: shoulder, leg/arm, waist, hand/wrist/finger, neck, and arm/elbow. Since the disease is mainly concentrated in the upper extremities, it appears as a decrease in grip strength.

Work-related musculoskeletal disorders are known to be caused by a combination of various factors such as demographic characteristics, social and psychological characteristics, and lifestyle habits, along with physical stress applied to body parts, such as repetitive work, inappropriate work posture, and excessive use of force [26, 27]. Many workers in the beauty industry suffer from physical pain and mental stress.

Depending on the nature of the work, workers are exposed to musculoskeletal diseases. Still, due to the nature of the work, some aspects are difficult to mechanize, which remains an ongoing problem [9]. The unique human service characteristics of the beauty industry that cannot be mechanized, even if the industry develops, include long working hours, posture during procedures, use of equipment, exposure to chemicals, inhalation of fine dust, irregular eating habits, work-related stress, etc., which affect workers psychologically and physically. There are many problems arising from this, and access to health care and exposure to diseases due to work have yet to be adequately addressed [28].

This study showed a correlation between occupation and grip strength ($p < .01$). These results indicate whether occupation affects physical functioning. Bongers, et al. [29] studied musculoskeletal health problems according to occupation and found that repetitive work can cause issues related to muscle strength. According to Bagayev, et al. [7], the group with the highest workload among middle-aged workers had the lowest strength and muscular endurance, similar to the results of this study.

In this study, no difference was found in the right-hand grip strength of hair designers compared to college students, but the left-hand grip strength decreased by 66.3%. Bagayev, et al. [7] found that among middle-aged workers, the group with a high workload had the lowest strength and muscular endurance due to repetitive tasks and high stress, suggesting that jobs with a high workload may weaken muscle strength.

This can lead to muscle fatigue due to excessive workload and insufficient recovery time, resulting in a loss of strength. According to Bagayev, et al. [7], differences in muscle strength appear among women depending on the workload at work. In dynamic tasks, the maximum isometric grip strength of women receiving long-duration loads is approximately 86% to 88% of that of women receiving short-duration loads, respectively. In static work, women performing high-intensity tasks had 86% higher grip strength than women performing low-intensity tasks. Comparing the results of this study with those of Bagayev, et al. [7], the results of hairstylists who received low-intensity loads in dynamic work showed low grip strength, which was consistent with that of Bagayev, et al. [7], supporting the findings of this study.

The smart IoT grip device used in this study was evaluated by a small number of 23 people, which is a limitation of this study. The user evaluation results are summarized as follows. There was some dissatisfaction with the ease of installing smart devices, and improvements must be made.

User evaluations showed many positive responses regarding the user interface, interaction, reliability, and performance. This suggests the possibility of using smart IoT grip devices usefully in medical rehabilitation and performing interactive tasks in a virtual reality environment, which is expected to provide a new approach.

The smart IoT grip device used in this study is a grip strength measurement tool connected to a smartphone application. It is expected to contribute to the evaluation of physical health status, patient monitoring, and improvement of the rehabilitation process. It is essential for many activities that require well-coordinated hand and arm movements, and grip strength is sensitive to changes in biological functions related to growth and aging. It is used as an indicator of muscle strength [30]. Additionally, it is an important indicator that can evaluate an individual's muscle mass [31].

Hands are also used for returning to work and selecting an occupation after damage caused by an industrial accident. They can also be used as a standard for judging the level of child development, so their use is wide. As such, advances in grip strength measurement technology can potentially improve the efficiency of patient management and rehabilitation outcomes, as well as the prevention of chronic diseases through improved data collection and analysis capabilities.

This study's limitations include the limited number of study subjects, hair designers in their 20s, and the need for more consideration of work experience.

In addition, the usability evaluation should have included expert opinions, and it is necessary to expand the number of subjects. Future research requires subjects to consider various occupations, ages, and career backgrounds. Additional research is needed to examine the relationship with their grip strength.

This study analyzed the effect of occupation on hand grip strength, and the result that the right-hand grip strength was higher than the left hand was consistent with previous studies. The finding that hair designers have lower grip strength than female college students may be due to occupational characteristics, and the fact that strength and muscular endurance are lower in occupations with a high workload is similar to Bagayev, et al. [7] study. These results have important implications for understanding how occupational demands affect physical functioning.

Recent advancements in grip strength measurement technology, particularly through IoT-enabled devices, offer significant potential for enhancing our understanding of occupational health. These devices provide real-time feedback and detailed analytics, which can be instrumental in preventive and rehabilitative healthcare settings. For example, integrating grip strength measurements with other biometric data such as heart rate, motion tracking, and fatigue levels can create a comprehensive health profile for workers. This holistic approach can help identify early signs of musculoskeletal disorders and other occupational health issues, enabling timely interventions.

Moreover, the use of IoT devices in measuring grip strength can also contribute to the development of personalized health and fitness plans. By continuously monitoring grip strength and other related metrics, individuals can receive customized exercise and rehabilitation programs to improve muscle strength and overall health. This personalized approach enhances the effectiveness of interventions and encourages adherence to health and fitness regimes by providing tangible progress indicators.

Integrating such advanced technologies in occupational health also has implications for policy and workplace design. Employers can use data collected from IoT devices to assess the physical demands placed on workers and redesign tasks or workflows to minimize strain and injury risk. Additionally, these insights can inform the development of ergonomic tools and equipment that better support workers' physical needs, particularly in fields requiring repetitive hand and upper limb movements, such as hairdressing.

In conclusion, the utilization of smart IoT devices for grip strength measurement represents a significant step forward in occupational health monitoring. The data and insights gained from these devices can improve workers' health outcomes through early detection of potential issues, personalized interventions, and informed workplace design changes. Future research should explore the potential of these technologies, particularly in diverse occupational settings and across different demographic groups, to fully realize their benefits in promoting health and well-being in the workplace.

6. Conclusion

This study aimed to compare the grip strength of female hair designers and female college students and conduct a usability evaluation of a grip strength measuring instrument using a smart IoT digital device. The results showed that the grip strength of the right hand was higher than that of the left hand in all subjects, and the grip strength of hair designers was lower than that of female college students. While there was no significant difference in the right-hand grip strength between hair designers and college students, the left-hand grip strength of hair designers was 66.3% lower. Based on these findings, work involving low dynamic loads may result in a decrease in grip strength. These results highlight the importance of considering occupational demands when assessing muscle strength and developing targeted interventions.

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