buildings

MDPI

Article

A Study of the Effects of Handedness on Portable Angle Grinder Risk

Sung Bum Choi and Jong Yil Park *

Department of Safety Engineering, Seoul National University of Science and Technology, Seoul 018811, Republic of Korea; bumy.choi@samsung.com
* Correspondence: jip111@seoultech.ac.kr; Tel.: +82-(0)2-970-6508

Abstract: This study investigates the underlying cause of occupational hazards for left-handed construction workers when using portable angle grinders on construction sites. The study was conducted through a survey of 42 participants in South Korean construction companies to gather information on their tasks involving portable angle grinders. The survey covered handle preferences, grip strength assessment, and work posture observations. Furthermore, a qualitative comparison of the work risk for left-handed and right-handed construction workers using a handheld angle grinder for cutting was conducted. Results showed that the grip strength of a left-handed worker's dominant and non-dominant hands did not significantly vary, implying that grip strength does not significantly affect their work performance. However, left-handed workers exhibited a higher likelihood of accidents due to poor work postures. Improvements to workplace safety by ensuring the use of ambidextrous tools and promoting tailored safety measures and training for left-handed workers were recommended.

Keywords: left-handedness; portable angle grinder; work(grip) strength; work posture; construction industry; South Korea

Citation: Choi, S.B.; Park, J.Y. A Study of the Effects of Handedness on Portable Angle Grinder Risk. *Buildings* **2023**, *13*, 2811. https://doi.org/10.3390/buildings13112811

Academic Editor: Pramen P. Shrestha

Received: 10 October 2023
Revised: 1 November 2023
Accepted: 7 November 2023
Published: 9 November 2023

1. Introduction

The construction sector is distinct from other sectors in that it possesses certain attributes, including a heavy reliance on temporary workers, high job intensity, and hazardous working conditions [1,2]. This is particularly true in South Korea, where construction sites have low entry barriers, allowing anyone who has completed a mandatory 4 h safety and health education—regardless of their education, qualifications, or age—to work in the construction field. As a result, safety management on construction sites is relatively poor, leading to a higher frequency of industrial accidents compared to the level of technological advancement in the industry.

The "2022 Industrial Accident Fatality Statistics" published by the South Korean Ministry of Employment and Labor in 2023 show that there were 874 industrial accident fatalities in South Korea in 2022, with a fatality rate of 0.43% (Figure 1). Of these fatalities, 402 were in the construction industry, which represents 46% of all accident-related deaths and has a fatality rate of 1.61%, which is 3.7 times higher than the average, highlighting the exceptionally high risk of accidents in this sector.

Furthermore, when examining the statistics for 26,888 construction industry accidents in South Korea, they are categorized as follows: falls, trips/slips, struck by objects, and cutting/piercing accidents (Table 1). Among these, cutting/piercing accidents, which are closely associated with power tools, account for 11.5% of the total accident rate.

Power tools are portable tools equipped with an electric motor to provide rotational force for working on materials such as metal or wood. They are primarily operated by hand-gripping and are often used on construction sites (Figure 2). However, power tools are predominantly designed for right-handed users which, arguably, can result in increased safety risks for left-handed users on construction sites.

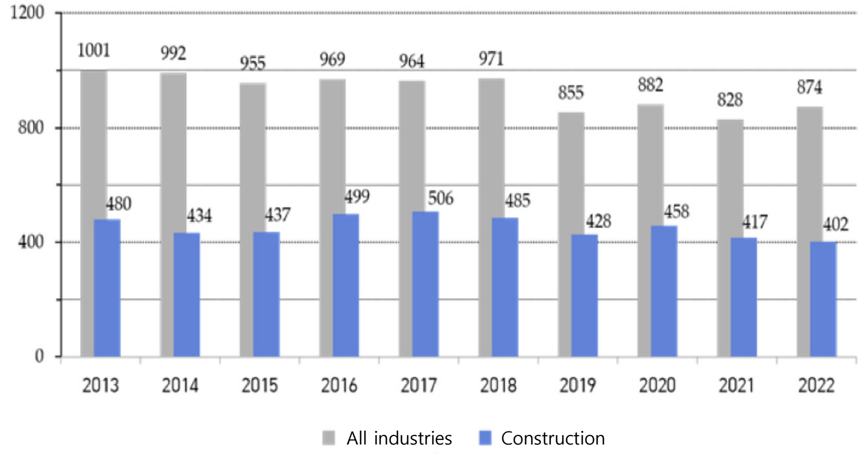


Figure 1. Number of deaths from industrial accidents over the past 10 years [3].

Table 1. Injury types in construction [3].

Injury Types	Number of Work Injuries (%)
Sum	26,888 (100)
Falls	8225 (30.6)
Slips	4685 (17.4)
Hit by objects	3535 (13.1)
Cuts/Lacerations/Piercings	3098 (11.5)
Collisions	2304 (8.6)
Entanglements	2336 (8.7)
Others	493 (10.1)

Figure 2. The electric power tools used on construction sites. (**a**) Hedge trimmer. (**b**) Core drilling machine. (**c**) Metal cut-off saw. (**d**) Portable angle grinder.

1.1. Background

1.1.1. Understanding Left-Handedness: Traits, Mechanisms, and Significance

There exist several techniques for categorizing handedness, including self-perception, the observation of preferred hand usage in daily life, determination based on handwriting, and practical assessments to evaluate manual dexterity. In neuropsychology, the Edinburgh Handedness Inventory and the Annett Questionnaire are commonly utilized questionnaires for measuring handedness [4].

Oldfield [5] created the Edinburgh Handedness Inventory, consisting of 10 items, as a questionnaire-based assessment criterion for classifying left-handedness (Table 2). However, Kang Yeong-uk [4] argued that, unlike American students for whom the hand used for writing is the representative factor for handedness, if an individual writes with their right hand but uses their left hand for activities like cutting with a knife, throwing a ball, or handling scissors, they should still be considered left-handed. To investigate the effect of handedness, the Edinburgh Handedness Inventory was utilized in this present study due to its widespread usage in handedness research.

Table 2. Edinburgh Handedness Inventory [5].

		Left	Right	Remarks
1	Writing			
2	Drawing			
3	Striking match			
4	Spoon			Laterality Quotient = ((R − L)/(R + L))100
5	Toothbrush			Left-handedness = Less than −40
6	Knife (without fork)			Ambidexterity = Between −40 and +40
7	Scissors			Right-handedness = More than +40
8	Broom (upper hand)			
9	Throwing			
10	Opening box (lid)			

Until now, research results have indicated that left-handed individuals make up approximately 10% of the total population. Carolien de Kovel et al. [6] analyzed data from 421,776 individuals, finding that the proportion of left-handed individuals was approximately 10.1%. In a study by Papadatou et al. [7], out of 2,396,170 subjects, the proportion of left-handed individuals was 10.6%. In South Korea, the percentage ranges from 4.8% to 8.2% [4,8–11]. However, due to the absence of international standards for handle classification, it is difficult to make absolute comparisons.

Research on the determinants of handedness, (right-handed, left-handed, or ambidextrous) has been ongoing for a long time and remains a subject of debate. The factors that influence handedness can be broadly categorized into genetic and environmental factors [12–14].

In 2020, Cuellar-Partida et al. [14] conducted an analysis of 1,766,671 individuals' genetic data and demonstrated that handedness is influenced by genetic factors. However, they also noted that genetic influences do not play a dominant role in handedness determination and that environmental factors have a greater impact.

This suggests that while genetics may contribute to handedness, the environment plays a more significant role in shaping handedness preferences and outcomes. The precise interplay between genetic and environmental factors in determining handedness continues to be a subject of ongoing inquiry and discussion in the scientific community. While the exact genetic and environmental factors that influence handedness remain the subject of ongoing research and discussion, this present study seeks to investigate the underlying cause of occupational hazards for left-handed construction workers when using portable angle grinders on construction sites.

1.1.2. Inconvenience and Injury Risk in Daily Life

Left-handed individuals, who live in a predominantly right-handed society and use right-handed tools, often experience ergonomic discomfort and a higher risk of injury [15–17]. Left-handed individuals often face difficulties when using tools designed for right-handed users. These difficulties range from physical to psychological effects. Physically, they may experience discomfort, pain, or even injuries such as hand cuts due to the improper design of the tools for their dominant hand. Psychologically, they may feel unable to perform tasks, and experience frustration, stress, and decreased skill. In the workplace, these issues can lead to decreased performance accuracy, dissatisfaction, and increased working time [18]. Most workplace environments and tool designs assume a right-handed orientation, which can arguably result in reduced efficiency and an increased likelihood of accidents and injuries for left-handed individuals [19].

According to a study conducted by Coren [19] with Canadian university students, left-handed individuals had a higher risk of accidents and related injuries in five activities (driving, work, home, sports, and tool usage) compared to right-handed individuals. This is because left-handed individuals may have to work with products designed and produced with implicit convenience for right-handed individuals, using their less proficient right hand, or adapting to different body postures and operating patterns. These adaptations can increase the risk of left-handed individuals experiencing accidental injuries.

1.1.3. Portable Angle Grinder

Portable angle grinders used on construction sites are compact, lightweight, and highly portable. They come with a variety of disc types, allowing for the grinding or cutting of various materials, including metals and nonmetals. In Korean construction sites, the most commonly used 4-inch grinder models can be compared as shown in Table 3.

Table 3. Commonly used 4-inch portable angle grinders.

Specification	Bosch [20] GWS 75-100S	Keyang [21] DG-850B
Input rate	720 W	850 W
No load speed	11,000 rpm	11,000 rpm
Disc diameter	100 mm (4″)	100 mm (4″)
Weight	1.8 kg	1.6 kg
Size (W × L × H)	73 × 270 × 108	

Portable angle grinders, while convenient and versatile, are known for being involved in frequent accidents and injuries. According to data from the Health and Safety Executive/Registration and Assessment Service (HASS/RAS) of the United Kingdom's Royal Society for the Prevention of Accidents (RoSPA) in 2001, portable angle grinders were ranked as the third most dangerous tool out of the top ten, with an annual occurrence of 5400 injuries, following knives (20,800 cases) and saws (6400 cases) [22].

In a study conducted by Kim Yong-hoon et al. [23] from 2011 to 2014 at Severance Christian Hospital in Wonju, South Korea, focusing on patients who had sustained injuries from power tools, it was found that the leading cause of accidents was electric saws (53%), followed by portable angle grinders (31.3%) and engine saws (15.7%). Accident types were also analyzed, with 80.2% of incidents involving contact with rotating parts and 8.2% involving kickback (as shown in Figure 3).

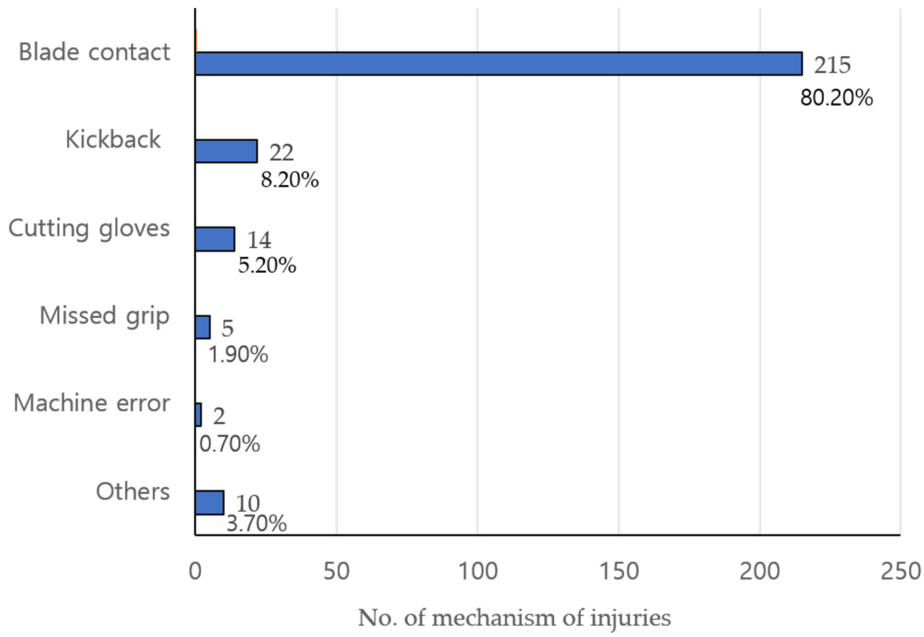


Figure 3. Types of injuries by power tools [23].

Multiple medical cases including facial injuries, hand injuries, and finger injuries, have been reported due to the operation of portable angle grinders [24,25]. Furthermore, in a study by Fritsche et al. [26] on the risk of finger amputations associated with the direction of handgrip in power tool operation, it was found that 35% of finger amputation patients were left-handed. The study reported that the probability of finger amputation injuries from using electric saws is 4.9 times higher for left-handed individuals compared to right-handed individuals.

However, while existing research has focused on analyzing data regarding the higher occurrence of safety incidents among left-handed individuals during power tool operation, there is a lack of research and analysis regarding the underlying causes of these safety incidents. Attempting to close this gap in the literature, the current study is focused on investigating the underlying factors of occupational hazards related to left-handed workers when using angle grinders on construction sites. The scope of this study encompassed handle preferences, assessment of grip strength, and observation of work postures.

2. Research Participants and Method

This study's objective was to examine two hypotheses related to the occupational hazards associated with the use of portable angle grinders by South Korean construction workers, with the aim of identifying the causes of safety incidents in left-handed workers.

To achieve this objective, we formulated two hypotheses:

- The first hypothesis suggested that left-handed individuals, due to the use of tools predominantly designed for right-handed users, face a higher risk of occupational hazards.
- The second hypothesis proposed that left-handed individuals, as a result of less safe work postures in comparison to right-handed individuals, experience increased occupational hazards.

2.1. Research Participants

For this study, a total of 42 participants were selected as research subjects. These participants were randomly chosen from among left-handed workers who use portable angle grinders at five construction sites of South Korean construction companies, considering factors such as the status of residential building projects. To compare the occupational hazards, an equal number of right-handed colleagues who perform the same tasks were also randomly selected. All selected participants exhibited a keen interest in participating in the survey.

The job positions of the research participants in the construction industry are presented in Table 4, which offers a summary of the number of subjects in various job categories for both right-handed and left-handed workers.

Table 4. Number of subjects on construction jobs.

Title 1	Earth Workers	Form Workers	Carpenters	Bricklayers	Drywall Finishers	Electricians	Mechanics	Others
Right-handed N = 21	5	5	1	3	2	1	2	2
Left-handed N = 21	4	5	2	2	3	1	2	2

The age range of the 42 participants spanned from their 20s to their 70s. The distribution of participants by age group was as follows: 1 participant was in their 20s (2.4%); 5 participants were in their 30s (11.9%); 11 participants were in their 40s (26.2%); 17 participants were in their 50s (40.5%); 7 participants were in their 60s (16.7%); and 1 participant was in their 70s (2.4%). Table 5 shows the age demography of participants. No female workers participated in the research—this is because in South Korea construction workers are predominantly males [27], and mostly male workers undertake any task involving the use of machinery.

Table 5. Age distribution of participants.

Title 1	20s	30s	40s	50s	60s	70s	Total
N (%)	1 (2.4)	5 (11.9)	11 (26.2)	17 (40.5)	7 (16.7)	1 (2.4)	42 (100)

2.2. Research Method

To test the two hypotheses, we conducted interviews to classify handedness, measured hand strength, and observed work postures.

2.2.1. Participant Interviews

Handedness classification was performed using Oldfield's Edinburgh Handedness Inventory (see Table 2). For each item, participants were assigned 2 points if they exclusively used either their right or left hand, and 1 point if they used both hands. The handedness classification was determined by the formula $(R - L)/(R + L)$, where R stands for the total score for the right hand and L represents the total score for the left hand. If the result was less than -40, the classification was left-handed; if it fell between -40 and $+40$, it was classified as ambidextrous; and if it exceeded $+40$, it was classified as right-handed.

2.2.2. Grip Strength Measurement

The grip strength was measured using a digital dynamometer (model: DW-781, S/N G201230058) observing the recommendations made by the National Fitness Certification South Korean Ministry of Culture, Sports, and Tourism [28]. First, in a standing position, we extended the arms at a 15-degree angle and took turns measuring the strength of the left and right hands twice. We recorded the highest score.

To find out the difference between right-hand and left-hand grip strength, a *t*-test was conducted, and the significance probability was set to 0.05% or less.

2.2.3. Observation of Work Postures by Expert Group

Finally, the work postures of left-handed and right-handed individuals using portable angle grinders were observed.

Portable angle grinders at construction sites serve various purposes, such as cutting and grinding, depending on the type of disc used. A presurvey was administered to the 42 research participants to gather information about their tasks involving portable angle grinders. The details of these tasks are presented in Table 6.

Table 6. Number of subjects performing grinder work (n = 42).

Always Cutting	Mainly Cutting	Half of Each	Mainly Grinding	Always Grinding
13 31.0%	22 52.4%	6 14.3%	1 2.4%	0 0%

In this study, the tasks involving portable angle grinders were limited to cutting operations. An expert group consisting of five individuals with more than 10 years of on-site experience in construction safety was selected. They observed a total of nine specific actions (Figure 4) from the start to the end of the cutting operation using portable angle grinders by construction workers. They qualitatively evaluated the level of risk by comparing the work postures of right-handed and left-handed individuals, considering factors such as attention to the point of operation.

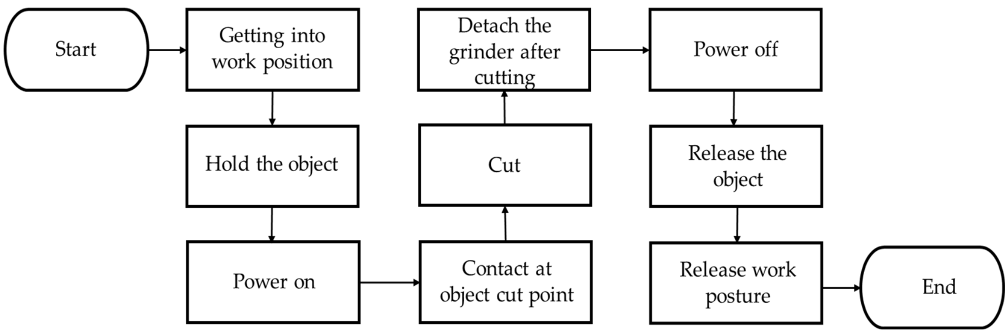


Figure 4. Activities for cutting with a portable angle grinder.

3. Result

3.1. Handedness Classification

Among the 42 participants in the study, all 21 who self-reported themselves as right-handed were classified as right-handed individuals using Oldfield's Edinburgh Handedness Inventory. However, among the eight participants who self-reported themselves as left-handed, three were classified as left-handed and five were classified as ambidextrous. Among the thirteen participants who self-reported themselves as ambidextrous, one was classified as left-handed, eight as ambidextrous, and four as right-handed. The discrepancies between self-report and Oldfield's handedness classification were evident.

Applying the research findings of Kang Yeon-wook [4] and Kim Soo-il [29], which suggest that individuals should be classified as left-handed if they perform all three activities (using a knife, throwing objects, and using scissors) with their left hand, the handedness classification is as shown in Table 7.

Table 7. Classification of handedness of left (ambidextrous)-handed.

	Left-Handed	Ambidextrous	Right-Handed
Self-reported	8	13	0
Oldfield	4	13	4
Kang Yeon-wook, etc.	12	5	4

When comparing handedness classification with the hand used for operating the portable angle grinder, it was observed that all 12 participants who identified as right-handed had their right hand as the operating hand for the portable angle grinder.

In contrast, among the eight participants who self-reported as left-handed, six had their left hand as the operating hand for the portable angle grinder, while two used their right hand. Among the 13 participants who self-reported as ambidextrous, 11 used their left hand for the portable angle grinder, 1 used both hands, and 1 used their right hand. Furthermore, among the four participants classified as right-handed based on the Oldfield test, three had their left hand as the operating hand for the portable angle grinder (Table 8). Considering these response patterns, it was reasonable to classify ambidextrous individuals as inclusive or potential left-handed individuals. However, it was noted that Oldfield's handedness classification method did not perfectly align with the hand used by left-handed construction workers for operating the portable angle grinder. This discrepancy can be argued to be due to the prolonged usage of the tool with their left hand to have a firm grip on the cut object using their right hand. Most of the workers also felt the tool was lightweight and could hold it with one of their hands.

Table 8. Four right-handed workers as a result of Oldfield.

Worker		Worker 1	Worker 2	Worker 3	Worker 4
Self-reported		Ambi	Ambi	Ambi	Ambi
Edinburgh Handedness Inventory	Writing	Right	Right	Right	Right
	Drawing	Right	Right	Right	Right
	Throwing	Right	Right	Right	Right
	Scissors	Right	Right	Left	Right
	Toothbrush	Left	Right	Right	Right
	Knife (without fork)	Left	Right	Left	Right
	Spoon	Right	Ambi	Right	Right
	Broom (upper hand)	Right	Left	Right	Right
	Striking match	Right	Left	Right	Left
	Opening box (lid)	Right	Right	Right	Right
EHI Result		Right	Right	Right	Right
Portable angle grinder gripping hand		Left	Right	Left	Left

3.2. Grip Strength

The results of measuring the grip strength of left-handed and right-handed individuals for both their left and right hands are presented in Table 9. It was observed that left-handed individuals had stronger grip strength in both their left and right hands compared to right-handed individuals. This finding is consistent with the results of Bechtol's [30].

Table 9. Grip strength of left-handed and right-handed individuals.

	Left-Hand Grip Strength	Right-Hand Grip Strength
Left (Ambi)-handed	47.65 kg	46.30 kg
Right-handed	41.76 kg	43.47 kg

Furthermore, the grip strength of the left hand was found to be stronger in left-handed individuals compared to right-handed individuals (Table 10). However, there was no significant difference in grip strength for the right hand between left-handed and right-handed individuals (Table 11).

Table 10. Comparison of the maximum grip strength of the left hand of left-handed and right-handed individuals.

	Mean (kg)	SD	SE	t	p
Left (Ambi)-handed	47.647	4.8518	1.1131	3.186	0.003
Right-handed	41.762	6.5932	1.4388		

Table 11. Comparison of the maximum grip strength of the right hand of left-handed and right-handed individuals.

	Mean (kg)	SD	SE	t	p
Left (Ambi)-handed	46.300	6.9369	1.5914	1.160	0.253
Right-handed	43.167	8.3527	1.8227		

Based on the grip strength measurement results mentioned above, it can be interpreted that grip strength is not the primary cause of the increased risk of accidents for left-handed workers using portable angle grinders. This outcome could be the result of several additional causes, including the lightweight perception of the tool by the participants, however, the hypothesis suggesting that left-handed construction workers using portable angle grinders for cutting operations have a higher level of risk due to grip strength factors in their non-dominant hand (right hand) compared to right-handed individuals can be rejected.

3.3. Working Postures

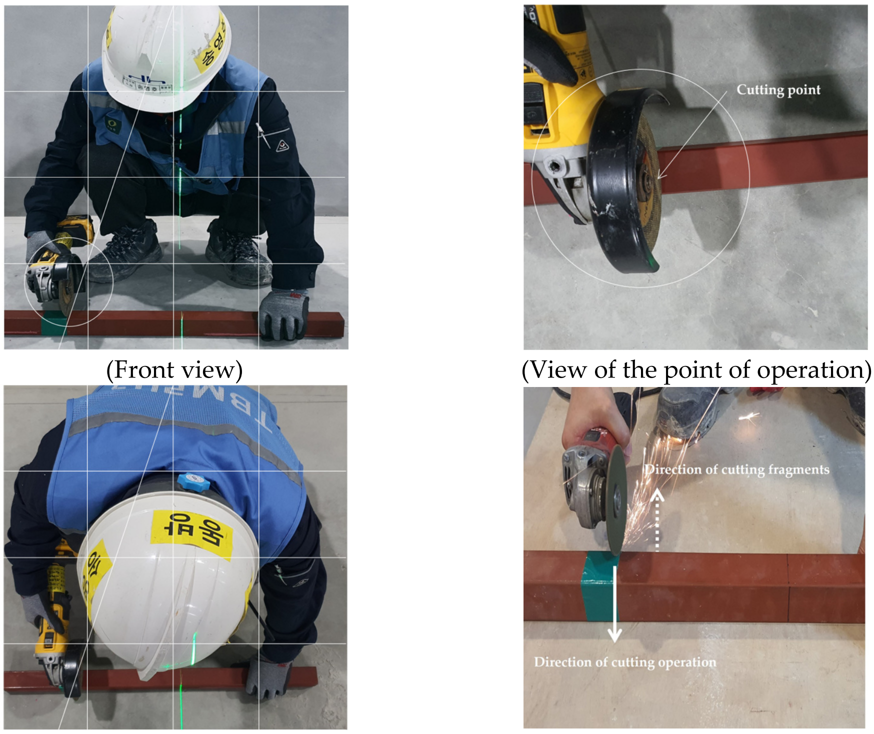
Working postures in a construction site can pose a risk of musculoskeletal disorders as prolonged or repetitive exposure to awkward or poor postures can place excessive stress on the neck, trunk, and wrists, potentially causing injuries and chronic musculoskeletal issues [31]. The portable angle grinder working postures of right-handed and left-handed construction workers were compared.

Right-handed people held the portable angle grinder with their right hand and the cutting object with their left hand. Having equally distributed body weight over both feet, the head could be turned to the right to observe the disc contact at the cutting point, i.e., the point of operation(Table 12). Cutting fragments also flew to the rear and did not obstruct the view of the point of operation (Figure 5).

Table 12. Observation of right-handed workers cutting with portable angle grinder.

Process	Field Observation
Start	
Get into work position	Maintain core strength while balancing on two legs
Hold the object	Hold the object with left hand at a certain distance away from the point of operation
Power on	Hold the grinder with right hand and push the power button with thumb
Contact at object cut point	Watch point of operation (in » out), contact when the wheel reaches full speed
Cut	Watch point of operation (in » out), cutting debris scatters backward
Detach the grinder after cutting	Watch point of operation (in » out), maintain the cutting angle
Power off	Power off with right thumb
Release the object	Release the object held by left hand
Release work posture	Relieve work posture before power off
End	

Subsequently, the work posture of left-handed construction workers using the portable angle grinder was observed. Unlike their right-handed counterparts, left-handed construction workers' work postures with the portable angle grinder were classified into four different types based on the hand holding the grinder, the direction of the cutting fragments, the focus on the point of operation, and other factors (Table 13).



(Front view) (View of the point of operation)

(Top view) (Direction of operation and fragments)

Figure 5. Right-handed.

Table 13. Working posture types of left-handed construction workers using portable angle grinder.

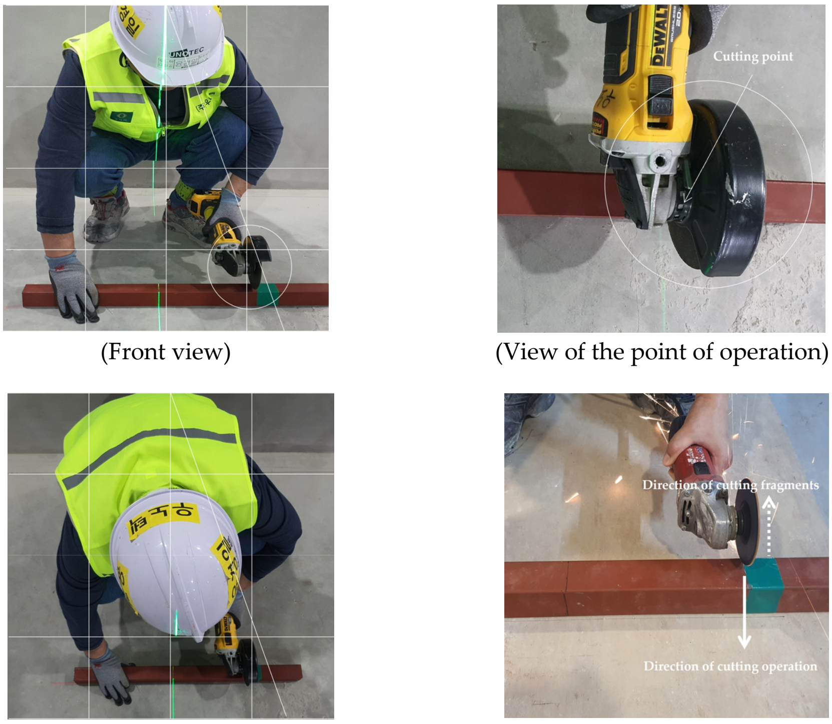
	Type A *n* = 3	Type B *n* = 4	Type C *n* = 3	Type D *n* = 11
Gripping hand	Right hand	Left hand	Left hand	Left hand
Direction of cutting fragments	Rearward	Rearward	Rearward	Forward
View of the point of operation	In » out	In » out	Out » in	In » out

Type A: This posture was observed in 14.3% of left-handed construction workers who participated in this study. This posture was identical to the work posture of right-handed workers who held the portable angle grinder with their right hand and performed the cutting. Relative to the work posture of right-handed workers, it was evaluated to have a similar level of relative work risk (Figure 6).

(Front view) (Top view)

Figure 6. Type A posture.

Type B: This posture was observed in 19% of left-handed construction workers. They held the portable angle grinder with their left hand and gripped the cutting target with their right hand. During the cutting operation, the worker's line of sight was obstructed by the body of the portable angle grinder, making it difficult to observe the point of operation. This posture was evaluated as having a higher risk of accidents and injuries, such as contact, kickback, and dropping, than in right-handed workers. Additionally, leaning the upper body forward to secure a line of sight increased the risk of injuries due to the proximity of the grinder's disc to the face, such as from cutting debris or sparks (Figure 7).



(Front view) (View of the point of operation)

(Top view) (Direction of operation and fragments)

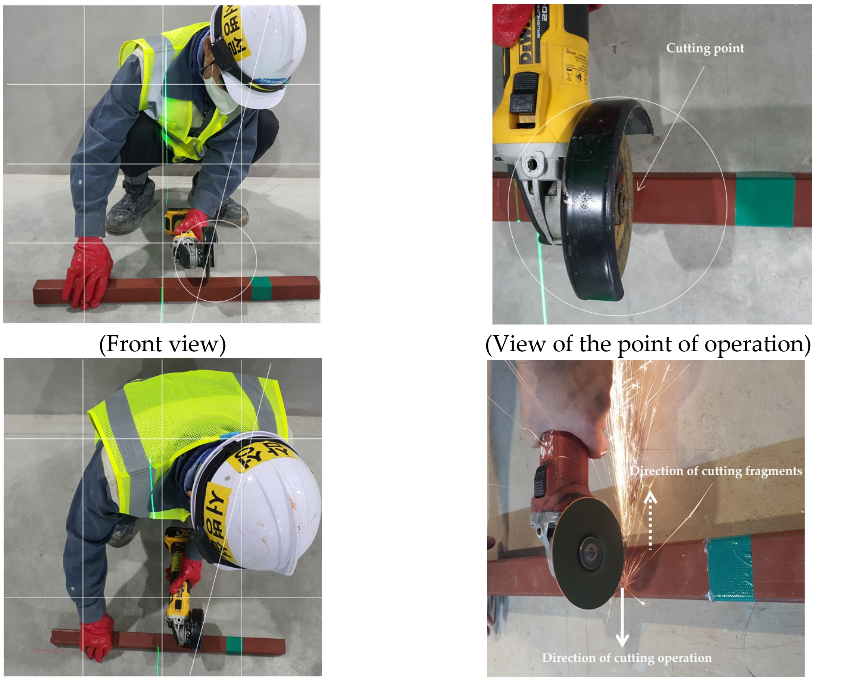
Figure 7. Type B posture.

Type C: This posture was observed in 14.3% of left-handed construction workers. Similar to Type B, they held the portable angle grinder with their left hand and gripped the cutting target with their right hand. However, they lean their upper body to the left to observe the point of operation from the outside. This posture was evaluated as having a higher risk of musculoskeletal disorders in the left knee and ankle due to the leftward shift of the body's center of gravity. Construction workers who adopted Type C posture reported experiencing pain in their left knee and ankle during or after cutting operations.

Placing the portable angle grinder disc on the inside of the upper body for monitoring the point of operation increased the risk of injuries, particularly to the face, upper body, and other areas during cutting operations, surpassing alternative postures.

Furthermore, it was assessed that, unlike right-handed construction workers, left-handed construction workers may face disadvantages in responding quickly to emergencies such as contact, kickback, and dropdown due to the skewed weight distribution in their posture during work (Figure 8).

Type D: This posture was the most common, accounting for over 52.4% of left-handed construction workers in the study. To initiate the cutting task, the worker needed to switch on the portable angle grinder using their left or right hand, and then rotate the portable angle grinder 180 degrees. This allowed them to grip the grinder with their working hand, which was typically the left hand. This process was due to the design of the portable angle grinder's power switch, which was tailored for right-handed convenience. Furthermore, during the cutting operation, the location of the portable angle grinder's power switch at the bottom made emergency braking difficult and was considered a significant safety risk.

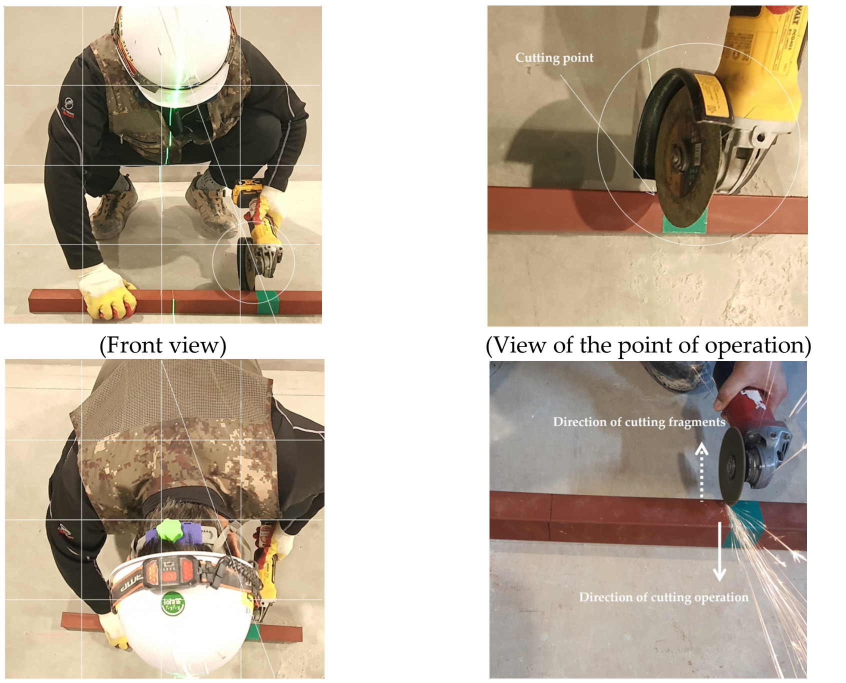


(Front view) (View of the point of operation)

(Top view) (Direction of operation and fragments)

Figure 8. Type C posture.

Additionally, Type D, unlike Types A, B, and C for left-handed workers and the right-handed work posture, poses a relatively higher risk of accidents and injuries, such as kickback, when cutting debris or sparks are scattered forward. This occurs particularly when cutting from the outside towards the inside (Figures 9 and 10).



(Front view) (View of the point of operation)

(Top view) (Direction of operation and fragments)

Figure 9. Type D posture.

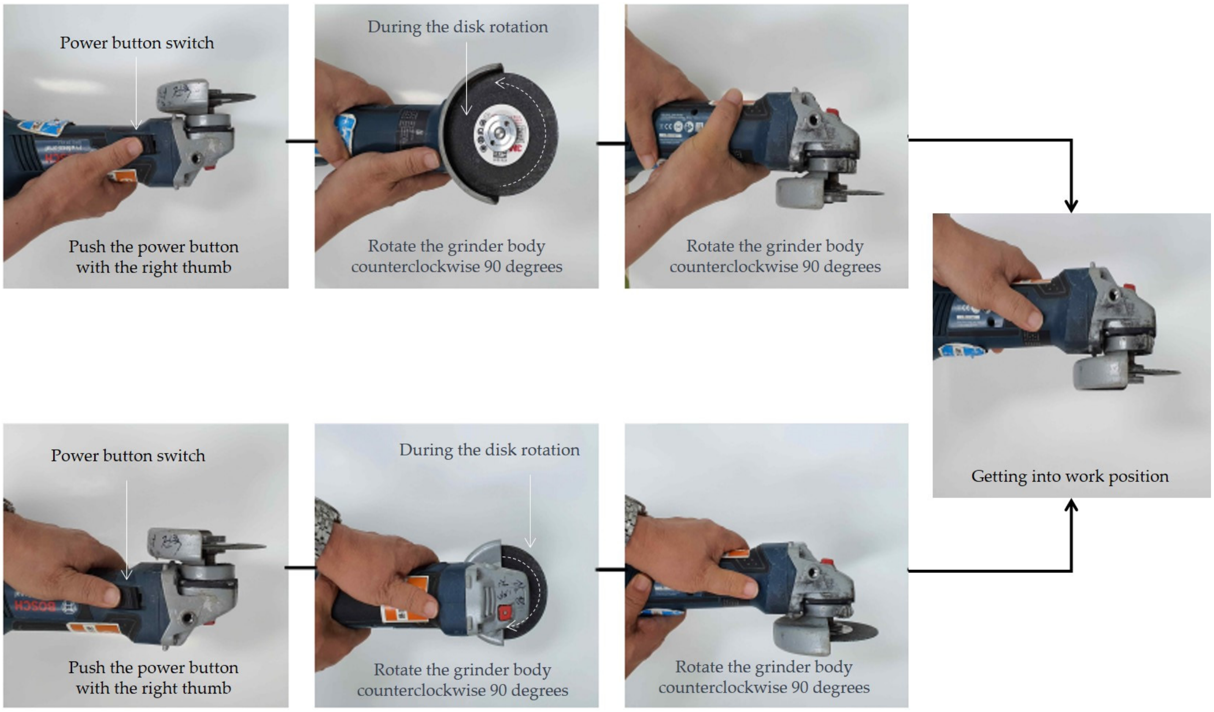


Figure 10. Observing the activation of the Type-D power switch.

As described above, a qualitative comparison of the work risk for left-handed construction workers using a portable angle grinder for cutting, compared to right-handed workers' posture, was conducted. The results are presented in Table 14.

Table 14. Relative comparison of the risk of left-handed subjects.

	Type A	Type B	Type C	Type D
Get into work position	$L \approx R$	$L \approx R$	$L > R$	$L \approx R$
Hold the object	$L \approx R$	$L \approx R$	$L \approx R$	$L \approx R$
Power on	$L \approx R$	$L \approx R$	$L \approx R$	$L > R$
Contact at object cut point	$L \approx R$	$L > R$	$L > R$	$L \approx R$
Cut	$L \approx R$	$L > R$	$L > R$	$L > R$
Detach the grinder after cutting	$L \approx R$	$L > R$	$L > R$	$L \approx R$
Power off	$L \approx R$	$L \approx R$	$L \approx R$	$L > R$
Release the object	$L \approx R$	$L \approx R$	$L \approx R$	$L \approx R$
Release work posture	$L \approx R$	$L \approx R$	$L > R$	$L > R$

Taking into account the results above, it may be said that left-handed construction workers have a higher risk of accidents when using the portable angle grinder with their left hand for cutting compared to using their right hand. Left-handed construction workers in Korea have developed their own methods of operation to adapt to working conditions where using a right-handed portable angle grinder is unavoidable. Consequently, this has led to difficulties in observing the point of operation, an imbalance in the upper body's center of gravity, and relative risks. Individual interviews with participants also revealed that 52.4% of left-handed workers had experienced near accidents related to portable angle grinder use, compared to 42.9% of right-handed workers. Additionally, 14.3% of left-handed workers reported having experienced injuries.

4. Conclusions

In this study, an investigation was conducted regarding the use of portable angle grinders by left-handed construction workers in South Korea, focusing on their work safety. The study involved 21 self-reported left-handed individuals and 21 right-handed individuals working at construction sites across five different locations in Korea. The key findings in this study were obvious in the Handedness Classification Discrepancy, grip strength, and working posture.

Based on the Edinburgh Handedness Inventory, all 21 of the right-handed participants were identified as being right-handed. However, among the 21 self-reported left-handed individuals, 3 were classified as right-handed, indicating a discrepancy between self-report and handedness classification. The measurement of grip strength (hand strength) revealed that left-handed individuals had higher maximum grip strength than right-handed individuals. Although there was a noticeable disparity in the grip strength between both hands for right-handed individuals, there was no significant difference for left-handed individuals. This suggests that grip strength factors such as disc contact, kickback, and dropdown do not pose a higher risk for left-handed individuals compared to right-handed individuals. Observation of left-handed individuals' work postures revealed four different types based on factors such as the hand used for gripping, the focus on the point of operation, and the direction of disc rotation. Type A was similar to the work posture of right-handed individuals, Type B indicated challenges in observing the point of operation, Type C inferred a likelihood of musculoskeletal disorders due to unbalanced weight distribution, and Type D represented a significant risk of accidental injury as it involved turning the portable angle grinder 180 degrees while gripping it with the left hand after activating the power switch.

From the observed postures, it can be argued that left-handed working postures presented problems with vision, balance, and emergency response to workers.

Based on the study's findings, the following managerial suggestions are made: (1) ensure the use of a more ambidextrous tools in workplaces by encouraging manufacturers to redesign tools to be more inclusive and ergonomically safe for left-handed users; and (2) promote workplace safety of left-handed workers by ensuring tailored safety measures (for example ensure their work task and site is not predominantly designed for right-handed workers) and training programs that consider the characteristics of left-handed workers.

This research contributes to our understanding of the underlying factors of the occupational hazards faced by left-handed construction workers and underscores the importance of addressing these challenges to create a safer working environment in the construction industry. Nonetheless, the study has some limitations that may be considered in further research such as only three factors and 42 participants comprising mostly male workers in the South Korean construction industry were investigated. In future studies, it is recommended that more underlying factors be considered and diverse geographical locations be investigated to reflect a diverse and more comprehensive argument on the topic. Also, more participants including male and female workers can be investigated to reflect a balanced demographical analysis.

Author Contributions: Methodology, data collection and analysis, visualization, writing—original draft preparation, and editing, S.B.C.; methodology, conceptualization, writing—review, and supervision, J.Y.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author, J.Y.P., upon reasonable request. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lee, D.; Yi, W. A study on indicators for safety inspections at domestic construction sites based on the type of industrial accident occurrence. *J. Korean Soc. Hazard Mitig.* **2021**, *21*, 1–14. [CrossRef]

2. Shim, G. Main problems and suggestions on occupational safety and hygiene in construction site. *J. Korean Soc. Occup. Environ. Hyg.* **2012**, *22*, 329–336.
3. Korea Occupational Safety and Health Agency (KOSHA). Available online: https://www.kosha.or.kr/ (accessed on 21 July 2023).
4. Kang, Y.W. Who is left-handed? Assessment of handedness among Koreans. *Korean J. Clin. Psychol.* **1994**, *13*, 97–113.
5. Oldfield, R.C. The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia* **1971**, *9*, 97–113. [CrossRef] [PubMed]
6. De Kovel, C.G.; Carrión-Castillo, A.; Francks, C. A large-scale population study of early life factors influencing left-handedness. *Sci. Rep.* **2019**, *9*, 584. [CrossRef] [PubMed]
7. Papadatou-Pastou, M.; Ntolka, E.; Schmitz, J.; Martin, M.; Munafò, M.R.; Ocklenburg, S.; Paracchini, S. Human handedness: A meta-analysis. *Psychol. Bull.* **2020**, *146*, 481. [CrossRef] [PubMed]
8. Jeong, H. A study on the level of discomfort and injury experience of left-handed people when using right-handed products. *Korean J. Saf. Manag. Sci.* **2009**, *11*, 35–41.
9. Jeong, H.; Jeong, H. Survey and ergonomic analysis on hand dominance. *J. Korean Soc. Ind. Eng.* **2004**, *30*, 165–174.
10. Han, S.H.; Nam, K.S.; Ahn, T.G.; Dan, J.M. Statistical analysis of grip strength and grip strength of normal Korean hands. *J. Korean Orthop. Soc.* **2009**, *44*, 219–225. [CrossRef]
11. Jeong, J.Y.; Jeong, D.H. Analysis of prospective elementary school teachers' perception of handedness. *Pract. Educ. Res.* **2017**, *23*, 225–241.
12. Corballis, M.C. From mouth to hand: Gesture, speech, and the evolution of right-handedness. *Behav. Brain Sci.* **2003**, *26*, 199. [CrossRef] [PubMed]
13. Wiberg, A.; Ng, M.; Al Omran, Y.; Alfaro-Almagro, F.; McCarthy, P.; Marchini, J.; Bennett, D.L.; Smith, S.; Douaud, G.; Furniss, D. Handedness, language areas, and neuropsychiatric diseases: Insights from brain imaging and genetics. *Brain* **2019**, *142*, 2938–2947. [CrossRef] [PubMed]
14. Cuellar-Partida, G.; Tung, J.Y.; Eriksson, N.; Albrecht, E.; Aliev, F.; Andreassen, O.A.; Barroso, I.; Beckmann, J.S.; Boks, M.P.; Boomsma, D.I.; et al. Genome-wide association study identifies 48 common genetic variants associated with handedness. *Nat. Hum. Behav.* **2021**, *5*, 59–70. [CrossRef]
15. Arora, A.; Saiya, P. Effect of handedness in professional dentists. *J. Dent. Allied Sci.* **2018**, *7*, 13. [CrossRef]
16. Heejin, O. A study on the difficulties of left-handedness in dental school clinical education: A narrative study of prospective dentists. *Med. Manag. Res.* **2020**, *14*, 49–62.
17. Coren, S.; Halpern, D.F. Left-handedness: A marker for decreased survival fitness. *Psychol. Bull.* **1991**, *109*, 90. [CrossRef] [PubMed]
18. Baghaee, H.; Emami, K.H.; Fard, A.N. Evaluating Inappropriate Tool Application Damages for Left-Handers. *Int. J. Occup. Hyg.* **2020**, *12*, 310–326.
19. Coren, S. Left-handedness and accident-related injury risk. *Am. J. Public Health* **1989**, *79*, 1040–1041. [CrossRef] [PubMed]
20. Bosch Korea. Available online: https://www.bosch-pt.co.kr/ (accessed on 15 July 2023).
21. Gyeyang Tool. Available online: https://www.keyang.kr/ (accessed on 15 July 2023).
22. Curran, M.G.; Clesham, K.; Irwin, S.; Hughes, A.; Kennedy, M. Angle grinder injuries in orthopedics: A case series and review of the literature. *Trauma Case Rep.* **2021**, *32*, 100413. [CrossRef] [PubMed]
23. Kim, Y.H.; Choi, J.H.; Chung, Y.K.; Kim, S.W.; Kim, J. Epidemiologic study of hand and upper extremity injuries by power tools. *Arch. Plast. Surg.* **2019**, *46*, 63–68. [CrossRef]
24. Sudhoff, H.; Schulte am Esch, J.; Ay, N.; Todt, I. Management of Complex Facial Injuries: Cutting Traumas by Angle Grinders. *Int. J. Otolaryngol.* **2020**, *2020*, 1891250. [CrossRef]
25. Abdoli, A.; Amirjamshidi, A. Work-Related Penetrating Head Trauma Caused by Industrial Grinder Tool (Case Report). *Arch. Iran. Med.* **2009**, *12*, 496–498.
26. Fritsche, S.A.; Lindell, A.K. On the other hand: The costs and benefits of left-handedness. *Acta Neuropsychol.* **2019**, *17*, 69–86. [CrossRef]
27. Construction Workers Mutual Aid Association. Available online: http://www.cw.or.kr/ (accessed on 15 July 2023).
28. National Fitness Award. National Fitness Certification Provided by the South Korean Ministry of Culture, Sports, and Tourism. Available online: https://nfa.kspo.or.kr/ (accessed on 21 July 2023).
29. Kim, S.I.; Kim, W.S.; Cho, K.J. The type of handedness and correlation analysis of handedness assessment items on university students in Korea. *Korean J. Phys. Anthropol.* **2008**, *21*, 245–253. [CrossRef]
30. Bechtol, C.O. Grip test: The use of a dynamometer with adjustable handle spacings. *JBJS* **1954**, *26*, 820–832. [CrossRef]
31. Henny, P.A.; Floris, C.B.; Edwin, S.; Jati, U.H. Evaluation of Working Posture of Construction Workers: A Case Study on Wall Construction Using Lightweight Bricks. *Civ. Eng. Archit.* **2023**, *11*, 64–71. [CrossRef]