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Handgrip strength asymmetry and occupational fitness in Korean coast guard officers: A cross-sectional study

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Abstract

Handgrip strength (HGS) is a widely recognized indicator of muscular function and overall health. Beyond absolute values, grip strength asymmetry has recently been identified as a predictor of functional decline, fall risk, and occupational performance. However, little evidence exists regarding HGS in maritime law enforcement personnel, such as Coast Guard officers, whose duties demand balanced upper limb function for rescue, security, and operational tasks. This cross-sectional study included 120 active-duty Korean Coast Guard officers enrolled in a basic job training program. Hand dominance was determined by self-report, and maximum grip strength of both hands was assessed using a digital dynamometer. Asymmetry was calculated as the absolute difference between the two hands divided by the stronger hand, expressed as a percentage. Clinically meaningful asymmetry was defined as ≥10%. Analyses included paired t-tests, one-way ANOVA across age groups (20s, 30s, 40s, ≥50s), and independent t-tests by sex. Results: Mean dominant HGS was 44.7±4.9 kg, significantly higher than non-dominant HGS (44.1±4.7 kg, $p < 0.001$). Average asymmetry was 7.4±4.8%, and 25.8% of participants exceeded the 10% threshold. Officers in their 30s exhibited the highest absolute HGS, while those in their 20s showed the greatest asymmetry despite relatively high strength. Male officers had significantly greater absolute HGS than females ($p < 0.001$), while asymmetry did not differ by sex. Korean Coast Guard officers demonstrated significant dominance in HGS, with asymmetry most evident in younger officers. These findings suggest that occupational fitness programs should emphasize not only absolute strength but also bilateral balance, particularly among early-career personnel. This study provides initial evidence to support tailored fitness and injury prevention strategies for maritime law enforcement.

Keywords: Coast Guard, Grip strength asymmetry, Handgrip strength, Law enforcement, Occupational fitness.

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Institutional Review Board Statement: Ethical review and approval were waived for this study because it involved the use of anonymized physical fitness data collected as part of official training programs of the Korean Coast Guard. The dataset did not include personally identifiable information, and all procedures complied with national and institutional research ethics guidelines.
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1. Introduction

Handgrip strength (HGS) is a widely used, simple, and non-invasive indicator of musculoskeletal function. It is closely associated with health outcomes such as aging, chronic diseases, functional independence, and mortality [1, 2]. Numerous epidemiological studies have demonstrated that reduced grip strength is related to physical decline, reduced mobility, and limitations in daily activities among older adults, and internationally, HGS has been adopted as a core measure for diagnosing sarcopenia and frailty. Thus, HGS is considered a highly valuable functional biomarker of overall health that can be assessed with minimal effort.

In recent years, not only the absolute value of grip strength but also bilateral asymmetry has gained attention as a novel predictor of health outcomes. Previous studies have reported that differences of 10% or greater between the two hands are strongly associated with impaired balance, decreased mobility, higher fall risk, and functional limitations [3, 4]. McGrath and colleagues demonstrated that grip strength asymmetry was a significant predictor of adverse outcomes in older adults in the United States, suggesting that evaluating asymmetry provides a more refined assessment of health status than absolute strength alone. Moreover, a recent meta-analysis concluded that upper limb asymmetry is widespread and consistently linked to reductions in functional performance [5].

These perspectives extend beyond older populations and are highly relevant for specialized occupational groups where physical capacity and functional balance are critical. Professions such as police officers, soldiers, and firefighters require exceptional physical fitness and symmetrical musculoskeletal performance to perform essential duties. For example, in police officers, grip strength has been shown to correlate with equipment handling, suspect restraint, and shooting performance [6, 7]. In military personnel, asymmetry between dominant and non-dominant hands has been associated with upper limb strength and overall operational performance [8]. Among firefighters, grip strength has similarly been identified as a key determinant of task performance and injury risk [9]. These findings highlight the importance of both absolute strength and symmetry for occupational efficiency and safety in tactical professions.

In Asian contexts, growing attention has been directed toward occupational fitness in police and military populations. Recent studies in Korea and Japan have emphasized that officers' musculoskeletal fitness, including grip strength, is closely tied to resilience against work-related stress, injury prevention, and long-term health maintenance. For instance, research on Korean police cadets indicated that baseline grip strength was strongly correlated with their overall training performance and ability to adapt to physically demanding tasks. Similarly, studies on Japanese self-defense forces have highlighted the significance of balanced strength for reducing musculoskeletal disorders, a finding that underscores the universality of grip strength as a fitness marker in East Asian populations.

Korean Coast Guard officers represent a unique tactical population tasked with diverse missions, including maritime rescue, law enforcement, and safety management. Unlike land-based professions, their duties are carried out in unstable environments characterized by waves, currents, and vessel motion, requiring not only absolute strength but also bilateral upper limb balance for stability and effective performance. In the United States, Coast Guard personnel are subject to standardized physical fitness assessments that include measures of muscular endurance and upper body strength, reflecting an institutional recognition of their importance for operational readiness. However, in Korea, evidence-based fitness standards tailored to the Coast Guard remain underdeveloped, and very limited research has been conducted on their specific occupational needs.

To address this gap, the present study assessed grip strength levels and asymmetry among Korean Coast Guard officers enrolled in the basic job training program, including lieutenants, inspectors, and senior inspectors. We evaluated dominant versus non-dominant hand strength, calculated asymmetry rates, and examined differences across age groups, sex, and rank. The findings aim to provide foundational evidence to inform health management and occupational fitness strategies for maritime law enforcement personnel.

2. Research Method

2.1. Study Design and Participants

This cross-sectional study was conducted among active-duty officers of the Korean Coast Guard who participated in the basic job training program at the Coast Guard Training Institute. A total of 120 officers were enrolled, consisting of

lieutenants, inspectors, and senior inspectors. Lieutenants and inspectors completed one week of online training followed by one week of on-site training, while senior inspectors completed one week of online training and two weeks of on-site training. The program included modules on maritime security, maritime safety, planning and operations, and general education. Grip strength measurement was conducted during the physical fitness assessment session of the on-site training.

The median age of participants was 44 years. The sample included 106 males (88.3%) and 14 females (11.7%). Hand dominance was determined by self-report, with 87 participants (72.5%) identifying the right hand and 33 participants (27.5%) identifying the left hand as dominant. All participants received an explanation of the study purpose and procedures and provided voluntary consent prior to measurement.

2.2. Measurement Tools and Procedures

Grip strength was measured using a digital dynamometer (Soundbody Grip, BioHealthCore, Korea). Measurements were performed in a standardized posture [1]. Participants sat in a chair with the shoulder in a neutral position, the elbow flexed at 90°, the forearm in a neutral position, and the wrist maintained in 0–30° extension. Each hand was tested at least once; when two trials were possible, the higher value was used for analysis.

All measurements were conducted by a trained examiner under consistent conditions. To prevent fatigue, measurements alternated between hands. Both dominant and non-dominant hand grip strengths were obtained following the same procedure, and the maximum value for each hand was used in the analysis.

To minimize external influences, the assessment was carried out indoors in a climate-controlled room, with ambient temperature maintained between 22–24°C. All participants were measured during daytime sessions between 9 a.m. and 12 p.m. to control for potential circadian variations in muscular performance. Examiners received prior training and followed a standardized testing script to ensure procedural consistency across all subjects. A pilot trial with 10 officers was performed before the main measurement to refine the testing protocol and verify instrument calibration.

2.3. Variable Definitions

The primary study variables were defined as follows. Dominant grip strength was recorded as the maximum grip strength of the self-reported dominant hand (right or left), while non-dominant grip strength referred to the maximum value from the opposite hand. Grip strength asymmetry was expressed as the absolute difference between the dominant and non-dominant hands divided by the stronger hand, and presented as a percentage. Clinically meaningful asymmetry was defined as a difference of 10% or greater [3, 4]. To improve robustness, additional sensitivity analyses were conducted using thresholds of 6.7% and 11.6%. Participants were also categorized into four age groups (20s, 30s, 40s, and 50s), and sex was classified as male or female.

3. Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA) and R version 4.3.2 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were summarized as means and standard deviations (SD). Paired t-tests were applied to compare dominant and non-dominant grip strength. Differences across age groups were assessed using one-way ANOVA followed by Bonferroni post hoc tests. Grip strength asymmetry was analyzed both as a continuous measure and as the proportion of individuals exceeding the 10% threshold. Sex differences were examined using independent t-tests.

In addition, test–retest reliability was verified by calculating Pearson's correlation coefficients from repeated measurements in a subset of participants. Data quality was ensured by double entry and cross-checking of all raw values. Outliers beyond three standard deviations were examined, and no extreme errors were identified. A two-tailed significance level of $p < 0.05$ was considered statistically significant for all analyses.

4. Results

4.1. Participant Characteristics

A total of 120 Korean Coast Guard officers participated in this study. The overall mean age was 43.8 years (SD = 7.6). The age distribution showed that 8 participants (6.7%) were in their 20s, 30 participants (25.0%) in their 30s, 54 participants (45.0%) in their 40s, and 28 participants (23.3%) were 50 years or older. Thus, the majority of the sample was concentrated in the 30s and 40s, reflecting the typical age structure of the active-duty Coast Guard population. Regarding sex distribution, 106 participants (88.3%) were male and 14 (11.7%) were female, with males representing the overwhelming majority. This distribution is consistent with the gender composition of the Korean Coast Guard, although the relatively small female sample size limits direct generalization of sex-specific findings. Hand dominance was self-reported, with 87 participants (72.5%) identifying the right hand and 33 (27.5%) identifying the left hand as dominant. This proportion is comparable to the general population, where right-handed dominance is common.

Table 1.
Participant Characteristics (n=120)

Variable	Value
Age (years, mean ± SD)	43.8 ± 7.6
20s / 30s / 40s / ≥50s, n (%)	8 (6.7) / 30 (25.0) / 54 (45.0) / 28 (23.3)
Male / Female, n (%)	106 (88.3) / 14 (11.7)
Right-hand dominant, n (%)	87 (72.5)
Left-hand dominant, n (%)	33 27.5)

4.2. Comparison of Dominant and Non-dominant Grip Strength

The mean dominant-hand grip strength for all participants was 44.7 kg (SD = 4.9), whereas the mean non-dominant hand grip strength was 44.1 kg (SD = 4.7). A paired t-test confirmed that dominant grip strength was significantly higher than non-dominant grip strength ($p < 0.001$), consistent with typical adult populations. However, the mean difference was relatively small (0.6 kg), suggesting that Coast Guard officers may use both hands in a balanced manner due to occupational demands. When analyzed by age group, the 20s cohort demonstrated a distinctive pattern: dominant grip strength averaged 38.5±9.6 kg, while non-dominant grip strength was 41.0±6.1 kg. Interestingly, this was the only group in which the non-dominant hand exceeded the dominant hand, with an average difference of 2.5 kg. Given the small sample size and wide variability within this age group, this finding likely reflects sample-specific variation rather than a true population trend. In the 30s group, grip strength reached the highest levels overall, with dominant hand strength at 46.6±3.2 kg and non-dominant hand strength at 45.1±4.6 kg. The 40s group displayed relatively balanced values (dominant 44.9±5.0 kg, non-dominant 44.6±4.9 kg), while the 50s group exhibited a modest decline in absolute strength (dominant 43.5±4.0 kg, non-dominant 43.0±4.1 kg), with only a 0.5 kg difference between hands. These results suggest that while grip strength tends to decrease with age, inter-hand balance appears to improve over time.

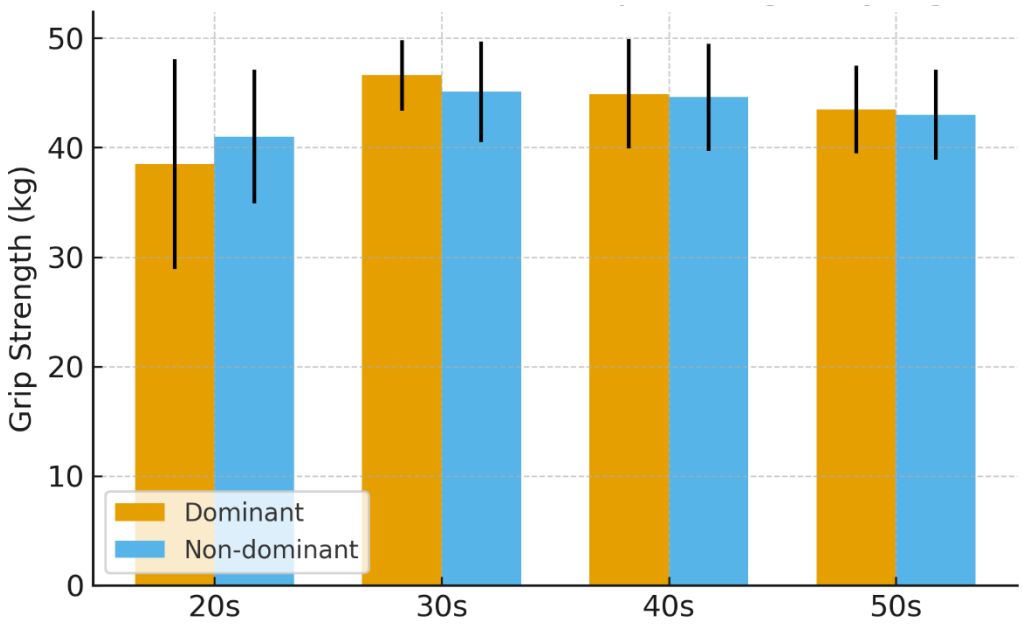

Figure 1.
Dominant vs Non-dominant Grip Strength by Age Group

4.3. Grip Strength Asymmetry

The overall mean grip strength asymmetry among participants was 5% (SD = 6%). Using the clinical threshold of ≥10% asymmetry, 31 officers (25.8%) were classified as having clinically meaningful imbalance, equating to approximately one in four participants. By age group, the 20s displayed the highest asymmetry with a mean of 14% (SD = 14%), indicating substantial variability within this group. Some individuals exhibited pronounced inter-hand differences. The 30s group showed a mean asymmetry of 6%, while the 40s and 50s groups recorded 3% and 4%, respectively. Thus, there was a clear downward trend in asymmetry with increasing age. The difference between the 20s and 40s was particularly striking (11 percentage points), though not statistically significant ($p = 0.08$), highlighting a strong trend toward improved balance with age. Sensitivity analyses further emphasized the influence of cutoff values. Using a 6.7% threshold, 46 participants (38.3%) met the criterion for asymmetry, while at the stricter 11.6% threshold, only 24 participants (20.0%) qualified. These findings demonstrate that prevalence estimates of asymmetry are highly sensitive to the chosen cutoff, underscoring the importance of consistent definitions in occupational health research.

Table 2.
Grip Strength and Asymmetry by Age Group.

Age group	Dominant HGS (kg, mean ± SD)	Non-dominant HGS (kg, mean ± SD)	Difference (kg)	Asymmetry % (mean ± SD)	≥10% Asymmetry n (%)
20s (n=8)	38.5 ± 9.6	41.0 ± 6.1	-2.5	14 ± 14	3 (37.5)
30s (n=30)	46.6 ± 3.2	45.1 ± 4.6	1.5	6 ± 5	9 (30.0)
40s (n=54)	44.9 ± 5.0	44.6 ± 4.9	0.3	3 ± 4	14 (25.9)
50s (n=28)	43.5 ± 4.0	43.0 ± 4.1	0.5	4 ± 4	6 (21.4)
Total	44.7 ± 4.9	44.1 ± 4.7	0.6	5 ± 6	31 (25.8)

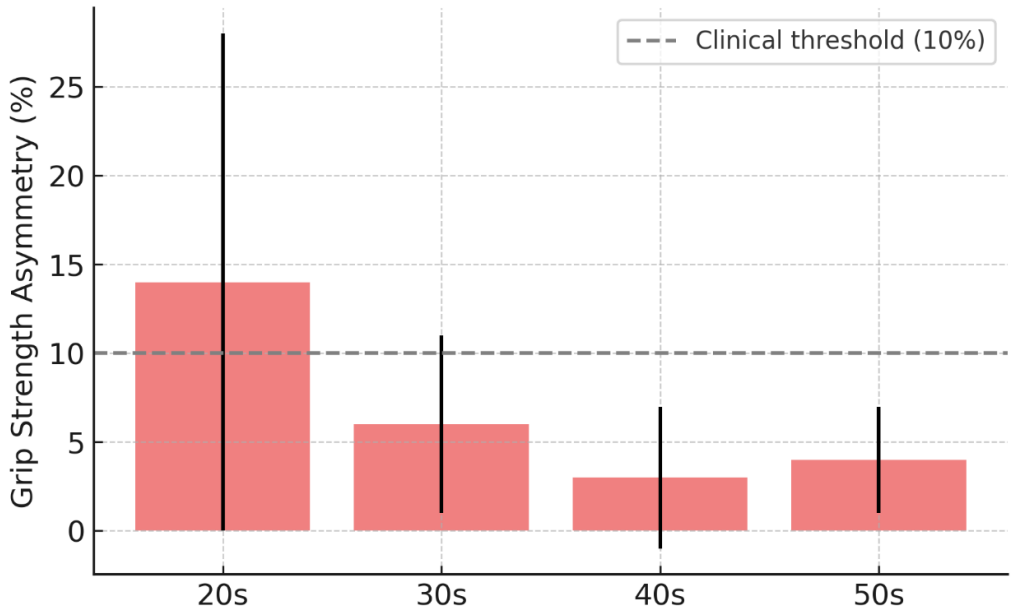

Figure 2.
Grip Strength Asymmetry by Age Group.

4.4. Sex Differences

Comparisons between males and females revealed substantial differences in absolute grip strength. For males, dominant hand grip strength averaged 45.7±4.0 kg, and non-dominant strength 45.1±3.8 kg. For females, dominant hand strength was 37.0±4.4 kg, and non-dominant strength 36.9±4.8 kg. Thus, female participants demonstrated grip strength values approximately 8–9 kg lower than their male counterparts, a difference that was statistically significant ($p < 0.001$). Despite this disparity in absolute strength, asymmetry percentages were similar across sexes. Males exhibited a mean asymmetry of 4% (SD = 6%), while females averaged 7% (SD = 5%). This difference was not statistically significant ($p = 0.62$). These results indicate that although women have significantly lower grip strength overall, their inter-hand balance is comparable to that of men. Interestingly, female participants demonstrated smaller within-group variability compared to males, suggesting more homogeneity in grip strength performance among women.

Table 3.
Grip Strength by Sex.

Sex	Dominant HGS (kg, mean ± SD)	Non-dominant HGS (kg, mean ± SD)	Difference (kg)	Asymmetry % (mean ± SD)
Male (n=106)	45.7 ± 4.0	45.1 ± 3.8	0.6	4 ± 6
Female (n=14)	37.0 ± 4.4	36.9 ± 4.8	0.1	7 ± 5
Total	44.7 ± 4.9	44.1 ± 4.7	0.6	5 ± 6

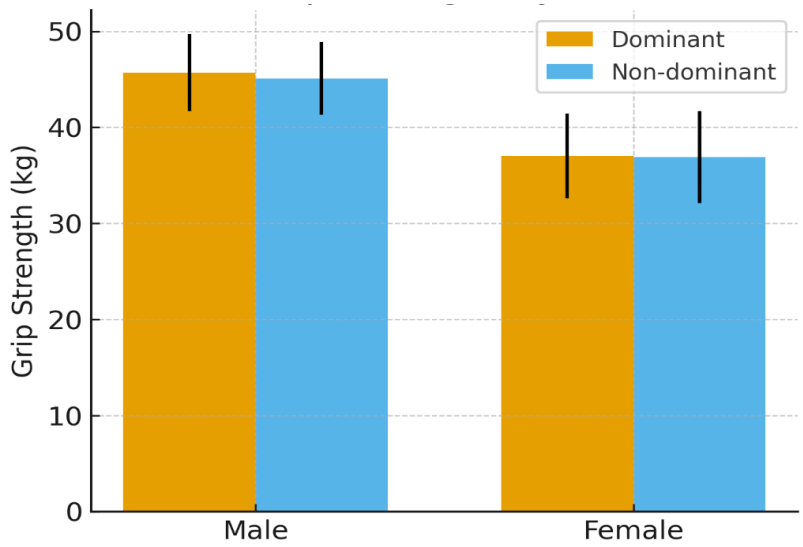

Figure 3.
Grip Strength by Sex.

4.5. Age Group Comparisons

One-way ANOVA revealed significant differences in dominant-hand grip strength across age groups ($p < 0.001$). Participants in their 30s demonstrated the highest average dominant-hand strength (46.6 ± 3.2 kg), while those in their 20s recorded the lowest (38.5 ± 9.6 kg). Officers in their 50s also showed reduced strength (43.5 ± 4.0 kg) compared with the 30s, indicating that grip strength peaked in the 30s and gradually declined thereafter. Post hoc analysis confirmed that the differences between the 30s and 20s, as well as between the 30s and 50s, were statistically significant. A similar age-related pattern was observed for non-dominant hand strength.

In contrast, grip strength asymmetry did not differ significantly across age groups ($p = 0.08$). Nevertheless, a clear trend was observed in which asymmetry was highest among officers in their 20s (14 ± 14%) and lowest among those in their 40s (3 ± 4%). This pattern suggests that although absolute strength declines with age, inter-hand balance improves, potentially reflecting adaptations from accumulated occupational experience and bilateral task demands that promote functional stability.

5. Discussion

This study evaluated grip strength and asymmetry among 120 active-duty Korean Coast Guard officers enrolled in the basic job training program, examining relationships with age, sex, and rank. Several key findings emerged. First, dominant hand strength was significantly greater than non-dominant hand strength across the cohort. Second, absolute grip strength declined with age, but inter-hand balance tended to improve. Third, women exhibited significantly lower absolute grip strength than men, but no sex differences were observed in asymmetry rates. Finally, officers in their 20s displayed both relatively high grip strength and the greatest degree of asymmetry. Collectively, these findings provide important insights into the physical fitness characteristics and occupational efficiency of Coast Guard officers.

5.1. Dominant Hand Superiority

The observation that dominant hand strength exceeded non-dominant hand strength aligns with patterns reported in the general population. Prior studies have shown that the dominant hand typically demonstrates a 10% strength advantage over the non-dominant hand [1, 2]. Interestingly, in the present study, the mean difference was modest at approximately 0.6 kg. This relatively small gap may be explained by the occupational demands of Coast Guard officers, who frequently utilize both hands in operational contexts. For instance, equipment handling, firearms use, and rescue activities often require substantial contributions from the non-dominant hand. The smaller asymmetry observed among Coast Guard officers compared with general adults is noteworthy and may reflect the balanced use of both hands inherent to their duties.

5.2. Age-Related Decline and Improved Symmetry

As expected, absolute grip strength decreased with advancing age. Officers in their 50s demonstrated an average of 6.6 kg less dominant-hand strength compared with those in their 20s. This pattern is consistent with prior research documenting age-related declines in muscular strength [3]. Notably, asymmetry rates declined with age. While McGrath et al. reported that asymmetry predicts health risks among older adults [4] our findings indicate a trend toward greater bilateral balance among middle-aged Coast Guard officers. This phenomenon may be attributable to the occupational environment, which demands continuous training and bilateral use of the upper limbs. Thus, although absolute strength diminishes with age, functional balance may be preserved or even enhanced through job-related physical activity.

5.3. Sex Differences

Marked sex differences in absolute grip strength were observed, with men demonstrating values approximately 8–9 kg higher than women on average. This finding reflects differences in muscle mass and body size and is consistent with prior reports [2]. However, no sex-based differences were found in asymmetry rates. Despite lower absolute strength, female officers exhibited bilateral balance similar to men. This suggests that asymmetry may be influenced more by usage patterns and training behaviors than by muscle mass alone.

5.4. High Asymmetry in Younger Officers

The highest asymmetry rates were identified in officers in their 20s, who showed an average asymmetry of 14%. This finding can be interpreted in two ways. First, the small sample size and high variability within this group may have exaggerated the effect. Second, younger officers at the early stages of their careers may rely more heavily on the dominant hand, particularly during training activities such as firearms use and equipment handling, which are often performed with a dominant-hand focus [7]. The combination of high absolute strength and marked asymmetry in this group underscores the need for targeted training to promote balanced bilateral function. Such interventions could enhance occupational efficiency and reduce injury risk [6].

5.5. Occupational Relevance

Grip strength is not merely a measure of physical capacity but also a critical determinant of occupational performance. In police and military populations, grip strength has been linked to equipment manipulation, firearms accuracy, and physical restraint skills [8, 9]. The relatively high levels of absolute grip strength observed among Coast Guard officers in this study are encouraging. However, asymmetry, even when present in a minority of individuals, may have negative consequences in tasks requiring stability, such as maritime rescue operations. Training programs for Coast Guard officers should therefore emphasize not only the enhancement of absolute strength but also the maintenance of bilateral balance.

5.6. Strengths and Limitations

This study has several strengths. It is one of the first to systematically analyze grip strength and asymmetry in a large sample of active-duty Coast Guard officers. Unlike previous research focusing on police, military, or firefighters, this study addresses an occupational group with unique demands. Furthermore, by explicitly distinguishing between dominant and non-dominant hands, the analysis provides greater precision than simple left–right comparisons. Several limitations must also be acknowledged. First, the small number of female participants (n=14) restricts the generalizability of sex-based comparisons. Second, the cross-sectional design precludes causal inference; longitudinal studies are needed to examine how asymmetry evolves and relates to occupational performance. Third, other relevant physical fitness measures (e.g., upper limb endurance, lower limb strength, or cardiorespiratory fitness) were not included, limiting the comprehensiveness of the findings. Fourth, variables such as training habits, work environment, and years of service were not fully accounted for in the analysis.

5.7. Future Directions and Practical Implications

Future research should include broader comparisons across tactical populations—police, military, and firefighters—to clarify the relationship between occupational demands and grip strength asymmetry. Equally important, standardized assessment protocols should be adopted to ensure reliability and comparability of HGS data across studies and populations [10]. Incorporating additional measures of physical capacity, such as lower limb strength and endurance, alongside direct assessments of job performance, would enhance understanding of how grip strength contributes to occupational readiness. From a practical standpoint, the results of this study can inform physical training and education programs for Coast Guard officers. The elevated asymmetry observed in younger officers highlights the importance of early intervention. Training curricula should include exercises that increase the use of the non-dominant hand and bilateral tasks, such as ambidextrous firearms drill or two-handed equipment handling. Such programs could help reduce asymmetry, enhance job performance, and mitigate injury risks.

6. Conclusion

This study systematically examined dominant and non-dominant hand grip strength and asymmetry among Korean Coast Guard officers, highlighting differences by age and sex. Overall, dominant hand strength was consistently greater than non-dominant hand strength. Absolute grip strength declined with age, whereas inter-hand balance improved. Female officers demonstrated significantly lower absolute grip strength compared to male officers, but no sex differences were observed in asymmetry. Notably, younger officers displayed high absolute grip strength but also relatively greater asymmetry, suggesting a need for targeted balance-oriented training early in their careers.

These findings carry important implications for occupational performance in maritime law enforcement. Tasks such as rescue, restraint, and equipment handling require not only absolute strength but also bilateral balance for safety and efficiency. Therefore, physical training programs for Coast Guard officers should emphasize both strengthening overall capacity and maintaining functional symmetry.

Future research should expand comparisons across tactical populations—including police, military, and firefighters—and employ longitudinal designs to clarify causal relationships between grip strength, occupational performance, and injury risk. As one of the first systematic studies to report on grip strength and asymmetry in Coast Guard officers, this work provides foundational evidence to guide the development of tailored fitness management strategies for specialized

occupations. These results highlight the importance of incorporating bilateral balance training into occupational fitness programs, thereby improving performance and reducing injury risk in maritime law enforcement

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