



## Occupational Comparison of Handgrip, Pinch Grip, and Response Time in Firefighters and Police Officers

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### *Abstract*

*International Journal of Exercise Science 19(2): 2009, 2026.* This study aimed to compare the bilateral handgrip strength (HGS), pinch grip strength (PGS), and dominant hand response time between firefighters and police officers. A total of 205 male participants (128 firefighters and 77 police officers) from Southwestern United States completed the study. HGS and PGS were assessed through three maximum-effort trials for each hand using Jamar hydraulic dynamometers, and response time was measured using Human Benchmark Software. The significance level for all analyses was set at  $\alpha = 0.05$ . Firefighters exhibited significantly greater bilateral HGS, palmar PGS, and tip PGS measures compared to police officers ( $p < 0.01$ ), with correlation coefficients ranging from  $r = 0.433$  to  $0.625$  for the dominant hand and  $r = 0.399$  to  $0.613$  for the non-dominant hand. Response time was shorter for firefighters than police officers ( $p = 0.022$ ). No significant differences were found in key PGS. Both groups showed strong positive correlations between bilateral HGS and response time ( $r = 0.619$  for firefighters and  $r = 0.705$  for police officers) and police officers showed strong to moderate positive correlations between HGS and PGS measures. Weak negative correlations were observed between response time and HGS and PGS measures ( $r = -0.0391$  to  $-0.247$ ). These findings highlight occupation-specific physical profiles and suggest targeted training programs could enhance job performance and reduce injury risk in both professions.

Keywords: First responders, law enforcement officers, fitness, occupational demands, occupational difference, fine motor skill

### **Introduction**

Handgrip strength (HGS) and pinch grip strength (PGS) are widely used indicators of hand function, upper body strength,<sup>4</sup> and overall muscular performance.<sup>1-5</sup> In occupations that require rapid, precise, and forceful manual actions, neuromuscular factors such as response time are also critical components of functional performance. Response time encompasses both the latency between stimulus presentation and movement initiation (reaction time) and the execution phase of the movement itself (movement time).<sup>7</sup> Together, upper extremity strength and response time contribute to an individual's ability to perform physically demanding task safely and

effectively. Strong hands, wrists, and fingers enable individuals to lift, manipulate, and control heavy loads for extended periods, while efficient response time supports timely and coordinated actions under dynamic conditions, skills that are essential for firefighters and police officers.<sup>6</sup> Various factors, including hand dominance, height, body weight, and age influence HGS and PGS.<sup>2</sup> Firefighters and police officers are routinely exposed to occupational demands that place substantial physical and cognitive strain on the upper extremities. Both professions involve high-intensity, unpredictable physical tasks requiring strength, speed, precision, and rapid decision-making.<sup>8,9</sup> Firefighters rely heavily on HGS and PGS to grip equipment, pull hoses, carry heavy loads, and perform rescues safely and efficiently.<sup>10,11</sup> Police officers similarly depend on hand strength for grappling, restraining suspects, victim rescues, and operating firearms.<sup>12</sup> In these contexts, response time plays a complementary role by supporting quick and coordinated motor responses during time-sensitive and high-risk situations.

Firefighting is particularly physically and cognitively demanding.<sup>13</sup> Previous research has demonstrated moderate associations between HGS and performance on simulated fire ground tests, suggesting that upper extremity strength contributes to occupational task efficiency.<sup>9,14</sup> Upper body strength has also been associated to faster task completion times, particularly in physically demanding firefighter activities.<sup>15</sup> Firefighters must also process complex sensory information, such as fire behavior, environmental shift, and teammate movements, while making rapid decisions.<sup>16</sup> Poor response time under such conditions may increase injury risk or compromise operational safety. Firefighters with reduced grip strength often experience difficulty performing critical task such as handling rescue equipment and maneuvering fire hoses.<sup>9,17</sup> Despite these demands, many firefighters do not engage in targeted training to improving HGS, PGS, or response time.

Police officers similarly involve intermittent bursts of intense physical exertion involving lifting, dragging, and physical restraint, interspersed with periods of lower activity.<sup>12,18</sup> Police officers depend on fine motor control and finger dexterity for tasks like firearm use, making both HGS and PGS essential for operational effectiveness.<sup>12,18</sup> Visual response time further supports their ability to respond quickly and accurately under pressure in unpredictable environments.<sup>19</sup> Together, strength and response time contribute to performance during high-stakes encounters where delayed or imprecise actions may have serious consequences.

Despite the recognized importance of HGS, PGS, and response time for occupational professions, limited research has examined these factors concurrently among firefighters and police officers. Therefore, this study aimed to examine within- and between-group associations in bimanual HGS, bimanual PGS, and dominant hand response time among firefighters and police officers in the Southwestern United States.

## **Methods**

### *Participants*

Full-duty career firefighters and uniformed police officers who were actively serving in departments across the Southwestern United States were recruited for this study. Inclusion criteria required participants to be at least 18 years old, actively working in their department, and willing to provide informed consent. Exclusion criteria included a history of hand fractures or broken bones within the past year or any diagnosed hand-related conditions (e.g., arthritis, carpal tunnel syndrome) within the past year. All participants were informed of the risks and

benefits of participation before signing the informed consent form. This study was approved by the University's Institutional Review Board, and was conducted in full accordance with the ethical standards of the *International Journal of Exercise Science*.<sup>20</sup> Sex was self-identified using a respectful and inclusive approach, allowing participants to self-report in their own words. No questions about gender identity or sexual orientation were asked unless relevant to the study's objectives.

The final sample consisted of 205 participants (128 firefighters and 77 police officers). The study was designed as an exploratory investigation of associations between upper extremity strength and response time in active-duty occupational population. An a priori power analysis was not conducted prior to data collection. Recruitment was based on voluntary participants and feasibility within active-duty fire and police departments, where availability during scheduled shift limited the ability to recruit to a predetermined sample size. Following data collection, a post hoc power analysis indicated that the achieved sample size ( $n = 205$ ) was sufficient to detect large between-group differences (effect size  $d \geq 1.0$ ) with statistical power  $(1-\beta) > 0.99$  at an alpha level of 0.05.

### Protocol

**Hand Anthropometrics:** Hand anthropometrics were measured for both hands to the nearest centimeter using non-elastic tape. Measurements were taken with the participant's forearm and hands in a supinated position, with the elbow supported on a table.<sup>21</sup> The wrist circumference was measured at the level of the radial styloid of the forearm.<sup>22</sup> Palmar width was measured from the radial side of the metacarpal of the second digit and the ulnar side of the fifth digit metacarpal.<sup>23</sup>

**Handgrip Strength and Pinch Grip Strength:** HGS was assessed using a Jamar hydraulic hand dynamometer (J.A. Preston Corporation, Clifton, NJ) following the guidelines of the American Society of Hand Therapists (ASHT).<sup>23</sup> The hand dynamometer was set at the second handle position for all the participants. A Jamar hydraulic pinch gauge dynamometer (J.A. Preston Corporation, Clifton, NJ, USA) was used to measure the tip, key, and palmar PGS. Tip PGS was measured by grasping the pinch gauge with the tip of the thumb and the index finger. Key PGS was measured by placing a pinch gauge between the pad of the thumb and the lateral aspect of the middle phalanx of the index finger. The palmar PGS was measured using a pinch gauge grasped between the pads of the thumb, index, and middle fingers.

The examiner held the distal end of the pinch dynamometer to prevent it from dropping. For the HGS and PGS, the participants sat in a straight-backed chair with both feet flat on the floor, elbows flexed at 90°, forearms in a neutral position, and wrists between 0°–30° extension and 0°–15° ulnar deviation. The arm is unsupported in space. The participants were instructed to exert maximum strength for three to five seconds during three consecutive maximum-effort trials. The average of three trials was recorded for each hand and finger strength measurement, with results rounded to the nearest kilogram (kg).<sup>24</sup>

**Response Time:** Response time was assessed using Human Benchmark Reaction Time Test, which evaluates simple response time involving both perceptual and motor components. A tablet was placed in front of the participant on a table with the Human Benchmark interface open. The test presents a visual stimulus (screen color change from red to green) at random intervals, requiring participants to detect the visual change and execute a rapid motor response by clicking the screen with their dominant hand.

Accordingly, the recorded response time reflects the combined latency of visual stimulus processing and motor execution, rather than an isolated measure of visual reaction time or motor movement time alone. Participants were instructed to click as quickly as possible when the screen changed color. Five trials were completed, and the mean response time (milliseconds) across trials was used for analysis.

### Statistical Analysis

Statistical analyses were performed using SPSS Version 27 (IBM Corporation., Armonk, NY, USA). Descriptive statistics for all variables were reported as mean (M)  $\pm$  standard deviation (SD). Pearson's bivariate correlations were conducted to examine within-group associations for dominant and non-dominant HGS, dominant and non-dominant key PGS, palmar PGS, tip PGS, and dominant hand response time separately for firefighters and police officers. Effect sizes for Pearson's  $r$  were interpreted as 0.10 (small), 0.30 (medium), and 0.50 (large).<sup>25,26</sup>

Independent sample t-tests were conducted to assess between-group differences in all continuous outcome variables. Independent sample t-tests were conducted to assess between-group differences in dominant and non-dominant HGS, key PGS, palmar PGS, tip PGS, and dominant hand response time. An alpha level of 0.05 was used to determine statistical significance. Effect sizes were reported using Cohen's  $d$ , with 0.2 considered small, 0.5 moderate, and 0.8 large.<sup>25</sup> Confidence intervals (95%) were reported for effect sizes where appropriate.

Intra-class correlation coefficients (ICCs) for HGS and PGS measures have been reported in previous literature to range from 0.85 to 0.98, demonstrating high test-retest reliability in adult populations.<sup>27,28</sup> The Human Benchmark Reaction Time Test was used to assess the simple response time. Although formal ICCs for this tool are not available, they have been used in previous studies to evaluate cognitive and visual-motor performance.<sup>29,30</sup> Due to the online and device-dependent nature of this test, the potential measurement variability related to hardware and software differences should be considered when interpreting the results.

## Results

Participants ( $n = 205$ ) consisted of firefighters ( $n = 128$ ) and police officers ( $n = 77$ ), ranging in age from 20 to 61 years old. No significant between-group differences were observed for height, right and left palmar size, or BMI. However, significant between-group differences were found for weight ( $p < 0.0001$ ) and wrist size ( $p < 0.0001$ ), with firefighters having greater weight ( $95.18 \pm 16.57$  kg) and larger right wrist size ( $95.18 \pm 16.57$  cm) and left wrist size ( $17.88 \pm 1.43$  cm) compared to police officers (Table 1 and 2).

**Table 1.** Anthropometric measures of Firefighters and Police Officers ( $n = 205$ ).

	Firefighters	Police Officers
Age (years)	35.45 $\pm$ 7.85	31.08 $\pm$ 8.22
Height (m)	1.78 $\pm$ 0.091	1.76 $\pm$ 0.08
Weight (kg)	95.18 $\pm$ 16.57 *	84.90 $\pm$ 14.86
Right Wrist Size (cm)	17.87 $\pm$ 1.36 *	16.72 $\pm$ 1.80
Left Wrist Size (cm)	17.88 $\pm$ 1.43 *	16.70 $\pm$ 2.01
Right Palmar (cm)	10.36 $\pm$ 1.34	10.41 $\pm$ 1.98
Left Palmar (cm)	10.14 $\pm$ 1.15	10.44 $\pm$ 1.88
BMI (kg/m <sup>2</sup> )	30.01 $\pm$ 4.30	27.18 $\pm$ 4.03

Note: Values are presented as mean  $\pm$  standard deviation. m = meters; kg = kilograms; cm = centimeters. Independent sample t-tests were conducted to assess between-group differences. \* = significant at  $p < 0.05$ .

Firefighters exhibited significantly greater strength in dominant HGS ( $p < 0.0001$ ,  $d = 1.066$ , 95 CI [0.75,1.35]) and all PGS measures (key PGS ( $p = 0.0002$ ,  $d = 0.17$ , 95 CI [-0.12, 0.45]) palmar PGS ( $p < 0.0001$ ,  $d = 0.78$ , 95 CI [0.49, 1.07]), and tip PGS ( $p = 0.045$ ,  $d = 0.69$ , 95 CI [0.40,0.98])). Firefighters also exhibited significantly shorter response time ( $p = 0.022$ ,  $d = -0.19$ , 95 CI [-0.47, 0.10]) than police officers.

**Table 2.** Handgrip, Pinch Grip, and Response Time of Firefighters and Police Officers ( $n = 205$ ).

	Firefighters (n = 128)		Police Officers (n = 77)	
	D Hand	ND Hand	D Hand	ND Hand
HGS (kg)	56.26 ± 11.71 *	54.86 ± 11.57	43.44 ± 12.82	42.03 ± 12.36
Key PGS (kg)	11.30 ± 1.97 *	11.23 ± 1.67	11.06 ± 4.50	10.78 ± 3.89
Palmar PGS (kg)	11.14 ± 2.19 *	10.77 ± 2.10	9.47 ± 2.05	9.02 ± 2.20
Tip PGS (kg)	8.05 ± 1.79 *	8.03 ± 1.89	6.85 ± 1.64	6.63 ± 1.68
Response Time (ms)	306.84 ± 48.77	-	317.33 ± 60.66*	-

Note: \*Indicates significant group differences between firefighters and police officers, HGS = handgrip strength, PGS = pinch grip strength, kg = kilograms, ms = millisecond, D = dominant, ND = non-dominant.

*Within-Group Correlations*

Both firefighters and police officers exhibited strong positive correlations between dominant and non- dominant HGS. In both groups, moderate positive correlations were observed between HGS and all PGS. Weak negative correlations between response time, HGS and PGS were also noted, with stronger relationships observed among police officers. The full correlation details, including statistical significance, are presented in Tables 3 and 4.

**Table 3.** Pearson’s Bivariate Correlations for Firefighters ( $n = 128$ ).

	D HGS	ND HGS	D Key PGS	ND Key PGS	D Palmar PGS	ND Palmar PGS	D Tip PGS	ND Tip PGS
ND HGS (kg)	.877**	--						
D Key PGS (kg)	.433**	.437**	--					
ND Key PGS (kg)	.460**	.557**	.783**	--				
D Palmar PGS (kg)	.570**	.534**	.558**	.530**	--			
ND Palmar PGS (kg)	.494**	.613**	.426**	.568**	.731**	--		
D Tip PGS (kg)	.425**	.432**	.501**	.525**	.625**	.490**	--	
ND Tip PGS (kg)	.399**	.399**	.407**	.612**	.390**	.496**	.720**	--
Response Time (ms)	-.170**	-.166	-.056	-.036	-.098	-.116	.004	.013

Notes: \*Correlation is statistically significant at  $p < 0.05$ , \*\* Correlation is statistically significant at  $p < 0.01$ , D = dominant, ND = non-dominant, HGS = handgrip strength, PGS = pinch grip strength, kg = kilogram, ms = millisecond.

**Table 4.** Pearson’s Bivariate Correlations for Police Officers (n = 77).

D HGS PGS	ND HGS	D Key	ND Key PGS	D Palmar PGS	ND Palmar	D Tip PGS	ND Tip PGS	
ND HGS (kg)	.928**	--						
D Key PGS (kg)	.577**	.560**	--					
ND Key PGS (kg)	.619**	.646**	.820**	--				
D Palmar PGS (kg)	.579**	.613**	.612**	.729**	--			
ND Palmar PGS (kg)	.415**	.519**	.462**	.678**	.786**	--		
D Tip PGS (kg)	.412**	.433**	.627**	.622**	.705**	.588**	--	
ND Tip PGS (kg)	.254**	.370**	.458**	.612**	.625**	.713**	.725**	
Response Time (ms)	-.311**	-.374**	-.345**	-.391**	-.374**	-.348**	-.247**	-.309**

Notes: \*Correlation is statistically significant at  $p < 0.05$ , \*\* Correlation is statistically significant at  $p < 0.01$ , D = dominant, ND = non-dominant, HGS = handgrip strength, PGS = pinch grip strength, kg = kilogram, ms = millisecond.

*Between-Group Correlations and Differences*

Significant strong positive correlations were observed between the dominant and non-dominant HGS in firefighters and police officers. Moderate positive correlations were found between HGS and all PGS measures within both groups, with coefficients ranging from  $r = 0.412$  to  $0.619$  for dominant HGS and all PGS and  $r = 0.370$  to  $0.713$  for non-dominant HGS. For police officers, HGS and all PGS measures were significantly correlated ( $p < 0.01$ ), ranging from  $r = 0.433$  to  $0.570$  for dominant HGS and PGS and  $r = 0.399$  to  $0.613$  for non-dominant HGS and all PGS.

Between-group differences were observed for dominant and non-dominant HGS ( $p < 0.001$ ), palmar PGS ( $p < 0.001$ ), tip PGS ( $p < 0.001$ ), and response time ( $p < 0.001$ ). No significant differences were found between the groups in the dominant and non-dominant key PGS. Firefighters demonstrated stronger dominant and non-dominant HGS, palmar PGS, and tip PGS, and exhibited shorter response times than police officers (Table 5).

**Table 5.** Handgrip, Pinch Grip, and Response Time of Firefighters and Police Officers (n = 205).

	Firefighters (n = 128)		Police officers (n = 77)		t	df	p	Effect
	M	SD	M	SD	size(d)			
D HGS (kg) *	56.26	11.72	43.44	12.82	-7.32	204	<.001	1.06
ND HGS (kg)*	54.86	11.57	42.03	12.36	-7.49	204	<.001	1.08
D Key PGS (kg)	11.30	1.97	11.06	4.50	-.523	204	.601	0.08
ND Key PGS (kg)	11.23	1.67	10.78	3.89	-1.09	204	.280	0.17
D Palmar PGS (kg)*	11.14	2.19	9.47	2.05	-5.41	204	<.001	0.78
ND Palmar PGS (kg)*	10.77	2.10	9.02	2.20	-5.69	204	<.001	0.82
D Tip PGS (kg)*	8.05	1.79	6.85	1.64	-4.78	204	<.001	0.69
ND Tip PGS (kg)*	8.03	1.89	6.63	1.68	-5.35	204	<.001	0.77
Response Time (ms)*	306.84	60.66	317.33	48.77	-5.59	204	<.001	0.19

Note: \*Differences are statistically significant at  $p < 0.01$ , D = dominant, ND = non-dominant, kg = kilograms, ms = millisecond, HGS = handgrip strength, PGS = pinch grip strength.

## Discussion

This study examined the relationship between bimanual HGS, PGS (key, palmar, and tip), and dominant hand response time among firefighters and police officers. Firefighters demonstrated greater bimanual HGS, palmar PGS, tip PGS, and shorter response time compared to police officers, with no significant between-group differences in bimanual key PGS. Across both groups, strong positive correlations were observed between bimanual HGS. Police officers showed more frequent strong-moderate positive correlations between bimanual HGS and all PGS measures, whereas firefighters' correlations between HGS and PGS were consistently moderate. Police officers also displayed weak negative correlations between both bimanual HGS and all PGS measures with response time, while firefighters showed this relationship only between dominant HGS and response time.

The greater absolute bimanual HGS, palmar PGS, and tip PGS in firefighters likely reflect the physically demanding nature of their work, which involves handling heavy equipment, carrying hoses, driving, climbing ladders and stairs, and performing rescues.<sup>21,31</sup> These tasks depend on strong HGS and PGS for control, and inadequate hand strength can increase the risk of tool mishandling, particularly when gloves are worn in high-temperature environments, posing safety risks to both firefighters and the public.<sup>32,17</sup> The absence of between-group differences in key PGS may indicate that fine pinch strength is less influenced by role-specific demands and more reflective of general hand function common to both professions. Structured, regular exercise opportunities, such as those available to firefighters at their station, lead to significant improvement in muscular strength, endurance, and firefighters task performance, supporting the idea that firefighters; access to on-site fitness facilities may contribute to their elevated strength levels.<sup>33</sup>

Strong bilateral HGS correlations in both groups suggest that balanced upper extremity strength is important for both groups' occupational performance, consistent with prior research.<sup>34</sup> For police officers, this balance supports tasks such as suspect apprehension, victim rescue, and firearm handling.<sup>35</sup> Tools like firearms, batons, and handcuffs require both HGS and PGS for control and precision, and previous studies have linked higher HGS, particularly in the non-dominant hand, to improved marksmanship and tactical performance.<sup>35,36</sup> This relationship may be context-dependent, with stronger associations reported in dynamic shooting scenarios compared to static ones.<sup>36</sup> Police officers' strong-moderate correlations between bimanual HGS and all PGS measures, compared to firefighters' moderate correlations, may reflect the precision-oriented demands of law enforcement tasks, where fine motor control and coordination are essential.<sup>35</sup> In contrast, firefighting tasks, such as victim drags, stair climbing, and equipment hoisting, require a large amount of upper extremity strength, muscular endurance, and anaerobic capacity,<sup>37</sup> which may explain the greater absolute strength in firefighters but weaker coupling between HGS and PGS. Occupational demands may partly explain lower absolute strength in police officers, as police officers' work often involves prolonged sedentary periods, such as vehicle patrols or administrative duties.<sup>36</sup>

Firefighters exhibited shorter response times compared to police officers. However, firefighters showed only a weak negative correlation between dominant HGS and response time, whereas police officers demonstrated a broader pattern of weak negative correlations between response time and both bimanual HGS and all PGS measures. These patterns may reflect the precision and decision-making demands of law enforcement tasks, which emphasize rapid visual-motor coordination rather than maximal force production.<sup>21,38</sup> Associations between forearm girth,

wrist circumference, and upper-extremity stability with shooting performance further support the interpretation that upper extremity strength contributes indirectly to response efficiency by enhancing movement control and stability.<sup>39</sup> Accordingly, response time findings should be interpreted within the context of integrated visual-motor performance rather than isolated motor speed.<sup>40</sup>

This study is not without limitations. This sample consisted exclusively of male participants; future studies should include both sexes to better reflect the occupational workforce. Although age was reported descriptively, it was not included as an analytic or stratification variable, despite its known influence on both upper extremity strength and response time. Future research should explicitly examine age-related differences in these outcomes. Response time was assessed using the Human Benchmark Reaction Time Test, which reflects simple response time involving combined visual processing and motor execution, rather than isolating visual or motor components. Accordingly, response time should be interpreted as a global measure of visual-motor performance. Finally, while HGS and PGS were measured using standardized guidelines, real-world occupational tasks differ between police officers and firefighters, which may limit the direct translation of laboratory-based measures to field performance.

This study demonstrates that while firefighters possess greater absolute bimanual HGS, PGS, and shorter response time, police officers exhibit a stronger interdependence between HGS and PGS, likely reflecting the precision demands that are needed for the occupation. These differences highlight the distinct physical profiles shaped by each profession's operational requirements. Integrating targeted HGS, PGS, and response time training into annual fitness programs for firefighters and police officers could aid in job performance, reduce injury risk, and improve occupational safety.

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