Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5, 83-91
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i5.6800

Comparison of grip strength between professional occupation soldiers and normal adult civilians

Hyo Taek Lee[1], Hyo Lyun Roh[2*]
[1]Department of Artificial Intelligence Big Data, Sehan University, Korea, take1682@sehan.ac.kr (H.T.L.).
[2]Department of Physical Therapy, Kangwon National University, Korea, withtry@kangwon.ac.kr (H.L.R.).

Abstract: This study aims to measure and compare the grip strength of soldiers and civilians, emphasizing its significance as an indicator of physical health and operational readiness. A cross-sectional study was conducted with 99 male participants (52 soldiers and 47 civilians) whose grip strength was measured using a Jamar hydraulic hand dynamometer. The results showed that military personnel had significantly higher grip strength (average 50 kg) compared to civilians (average 47 kg), with a robust 3 kg difference. No significant differences were observed across different age groups within the soldiers. The findings suggest that systematic military training positively influences grip strength development, reinforcing the role of structured physical conditioning in enhancing operational readiness. These outcomes advocate for integrating grip strength assessments and training into military fitness programs to improve combat preparedness. Furthermore, the results offer valuable insights for civilian physical training strategies focused on functional strength enhancement.

Keywords: *Civilians, Man, Grip strength, Military personnel, Physical fitness.*

1. Introduction

Grip strength, a crucial measure of muscular function and overall health, is widely recognized as a robust physical health biomarker [1]. Measurement of muscle strength through grip strength is evaluated as a useful method that is noninvasive, simple, and convenient for measurement [2]. It reflects individual physical capabilities and correlates significantly with the capacity to perform daily activities and manage health outcomes. The Jamar dynamometer, a standardized tool endorsed by Bohannon [1] has established itself as a reliable method for assessing grip strength, demonstrating a direct relationship between the measured grip strength and an individual's health status. This device's widespread acceptance in clinical and research settings underscores its significance in health assessments.

Furthermore, studies such as those by Rantanen, et al. [3] have highlighted the predictive value of grip strength, especially in older adults, where it serves as an early indicator of functional decline and a predictor of the ability to independently perform Activities of Daily Living (ADL). The implication of grip strength in predicting health deterioration related to aging presents a compelling case for its regular assessment across different populations, including those subjected to unique physical demands such as military personnel. In sports science, the importance of grip strength extends beyond basic health indicators to performance metrics. Research by Fernandez-Fernandez, et al. [4] and Beyer, et al. [5] has demonstrated that grip strength training can significantly enhance sports performance and reduce injury risks among athletes. This relevance of grip strength in high-performance settings is parallel to military training, where physical readiness and injury prevention are paramount.

The military context, in particular, offers a unique perspective on the utility of grip strength [6]. The arduous nature and intense occupational demands of the military are well known [7, 8]. According

History: Received: 10 February 2025; Revised: 15 April 2025; Accepted: 18 April 2025; Published: 3 May 2025
* Correspondence: withtry@kangwon.ac.kr

to Keeley, et al. [6] systematic grip strength training improves combat efficiency and readiness. This specific application of grip strength training in military training underscores the need for comprehensive physical conditioning programs that include grip strength as a core component. Strength training has been routinely used in exercise programs of military groups; however, no review has ever been conducted to clarify the selection of exercise tests to monitor its effectiveness [9].

Healthy physical fitness consists of strength, muscular endurance, flexibility, whole-body endurance, and body composition [10]. Muscle strength is one of the five health-related components of physical fitness, and given its importance to military performance, quantifying strength was of great practical importance [9]. Soldiers may also face additional stressors, including sleep deprivation, calorie restriction, and environmental extremes during training and deployment [7]. These occupational demands, therefore, require unique training with high levels of strength, endurance, speed, power, and agility crucial for soldiers to be physically and mentally prepared to operate effectively [11]. In particular, in South Korea, the importance of training programs for the military and their physical strength is highlighted more than in any other country due to the unique national defense situation of the confrontation between South Korea and North Korea. Therefore, it is necessary determine the level of soldiers' strength by measuring grip strength, which is considered an indicator of strength.

Given the established importance of grip strength in both civilian and military settings. The purpose of this study was to further investigate the effects of structured physical training on grip strength by comparing grip strength in military and civilian populations and to evaluate the potential impact of these findings on physical training programs. By doing so, the study seeks to provide empirical support for tailored training regimens that enhance not only military effectiveness but also promote physical health and functionality in civilian populations.

2. Research Design and Hypothesis

The purpose of this study is to measure and compare the grip strength of male professional soldiers and male citizens. As a cross-sectional study, the hypothesis was set as follows:

Hypothesis 1: Is there a difference in grip strength between male professional soldiers and male citizens?

Hypothesis 2: Is there a relationship between the level of grip strength and age in male professional soldiers?

Hypothesis 3: Is there a difference in grip strength between age and military rank?

3. Methods

3.1. Methodology and Participants

This study compared grip strength in military and civilian populations to evaluate the effect of structured physical training on grip strength. The sample size was determined using G*Power software, targeting an effect size of 0.5, an alpha level of 0.05, and a power of 0.95 [12].

The minimum sample size required for the t-test was 42 people, so this study met the sufficient sample size. This setting provided the performance necessary to detect significant differences between groups. A total of 99 participants in this study were 52 soldiers and 47 male civilians. The study's grip strength measurements were conducted between February and March 2024. Participants were voluntarily recruited from professional military personnel and general adult men. All participants were briefed on the study's purpose, procedures, potential risks, and benefits.

It was announced that one could quite midway and that doing so would be no disadvantage. Informed consent was obtained from each participant and ethical standards and participant rights were adhered to. The average age of the participants is shown in Table 1. The average age of the military group was 28.04 ± 5.52 years, and the average age of the civilian group was 27.11 ± 8.33 years, with no statistical difference between the two groups.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

Table 1.
Age of the participants.

	Professional occupation soldiers	Normal male civilians	t	p
N	52	47	0.592	0.556
Age(years)	28.04 ±5.52	27.11 ±8.33		

3.2. Instruments and Measurements

Grip strength was measured using the Jamar® Hydraulic Hand Dynamometer (USA), a device widely recognized for its reliability and validity in clinical assessments of hand grip strength [13]. Each participant underwent a grip strength assessment under controlled conditions to ensure consistency. Before measuring grip strength, an explanation and demonstration were given, and the subjects were allowed to practice once to measure it naturally before being measured. For soldiers, measurements were taken during breaks in a quiet office, and for civilians living in cities B and C in Korea, measurements were taken during breaks during work. The procedure involved participants seated with their arms positioned at a 90-degree angle on a flat surface, ensuring the forearm and wrist were aligned without support. Measurements were taken three times for each hand, with 3-minute rest intervals to minimize fatigue effects, and the highest value was recorded for analysis. The equipment used in this study is as follows Figure 1.

3.3. Ethical Considerations

The study procedures were rigorously designed to adhere to ethical guidelines set forth by the IRB (SH- IRB 2024-007), with particular attention to privacy, confidentiality, and the welfare of the participants.

Figure 1.
Measuring grip strength by Jamar Dynamometer.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

3.4. Data Collection and Statistical Analysis

Data collection included demographic details such as age, gender, and health status. This information was used to control for potential confounders in grip strength outcomes. The primary analysis involved an independent samples t-test to compare the mean grip strength between the military and civilian groups. Descriptive statistics were calculated for all variables, including means and standard deviations for grip strength across both groups.

A paired samples t-test was conducted to compare the difference in grip strength between the left and right hands. One-way analysis of variance was conducted to determine differences in grip strength by age group. A two-way analysis of variance was conducted to investigate the interaction between age and status on grip strength. Statistical significance was set at $p < .05$. All analyses were performed using SPSS software, version 26.0 [14].

4. Results

4.1. Grip Strength of Military and Male Civilian

An independent samples t-test was conducted to compare the grip strength of soldiers and civilians (Table 2).

As a result of analyzing the grip strength measurement results, a statistically significant difference was found between the civilian group (42.02 ± 8.16 kg) and the military group (48.20 ± 7.03 kg) in the left hand, and the military group showed a higher grip strength than the civilian group. ($p < 0.001$). In the right hand, there was a statistically significant difference between the civilian group (44.12 ± 7.56 kg) and the military group (52.29 ± 7.07 kg), with the military group showing higher grip strength ($p < 0.001$). Therefore, the grip strength of professional soldiers was found to be higher than that of civilians. This substantial difference not only underscores the effectiveness of regular physical training in the military but also suggests that such structured programs have a pronounced impact on enhancing physical capabilities (Table 2).

Table 2.
Comparison of Grip Strength between Soldiers and Civilians.

(N: 94, Unit: Kg)

Group		Professional occupation soldiers	Normal male civilians	t	p
Grip strength (M±SD)	Right hand	52.29±7.07	44.12±7.56	5.770	0.000
	Left hand	48.20±7.03	42.02±8.16	3.711	0.000

4.2. Age And Grip Strength of Professional Occupation Soldiers

To compare the grip strength of soldiers by age, a one-way ANOVA analysis of variance was performed (Table 3).

In the right hand, the difference in grip strength between those in their 20s (52.69±6.76), 30s (53.39±7.36), and 40s (60.00±8.72) was not statistically significant. On the left hand, the difference in grip strength between those in their 20s (47.57±7.31), 30s (48.23±5.45), and 40s (55.33±8.08) was not statistically significant. Therefore, there appears to be no difference in grip strength according to age among professional soldiers in their 20s, 30s, and 40s.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

Table 3.
Grip Strength by Age Group among Professional Soldiers.

(N: 52, Unit: Kg)

		N	Mean	SD	F	p
Right hand	20s	36	52.69	6.76	1.508	0.232
	30s	13	53.39	7.36		
	40s	3	60.00	8.72		
Left hand	20s	36	47.57	7.31	1.735	0.187
	30s	13	48.23	5.45		
	40s	3	55.33	8.08		

4.3. Age and Grip Strength of Professional Occupation Soldiers

To compare the pinch grip strength of soldiers by age, a one-way ANOVA analysis of variance was performed (Table 4).

On the right hand, the difference in pinch grip strength between people in their 20s (9.72 ± 1.65), 30s (10.29 ± 1.45), and 40s (10.33 ± 0.58) was not statistically significant. On the left hand, the difference in pinch grip strength between those in their 20s (9.64±1.93), 30s (10.17±1.34), and 40s (10.33±2.31) was not statistically significant. Therefore, there appears to be no difference in pinch grip strength according to age among professional soldiers in their 20s, 30s, and 40s.

Table 4.
Pinch strength of professional occupation soldiers.

(N: 52, Unit: Kg)

		N	Mean	SD	F	P
Right hand	20s	36	9.72	1.65	.657	.524
	30s	13	10.29	1.45		
	40s	3	10.33	.58		
Left hand	20s	36	9.64	1.93	.463	.633
	30s	13	10.17	1.34		
	40s	3	10.33	2.31		

4.4. Military Rank and Grip Strength of Professional Occupation Soldiers

We examined the grip strength of professional soldiers by military rank. There was no statistical difference in the grip strength of the right and left hands. The results are shown in Table 5.

Table 5.
Military rank and grip strength.

(N: 52, Unit: Kg)

	Rank	N	Mean	SD	F	P
Right hand	Corporal	5	50.40	4.34	0.403	0.805
	Sergeant	20	54.68	7.02		
	Staff Sergeant	14	52.71	6.45		
	Sergeant First Class	6	53.17	7.96		
	Major or higher	7	52.86	9.99		
Left hand	Corporal	5	44.40	4.34	0.554	0.697
	Sergeant	20	49.42	8.02		
	Staff Sergeant	14	47.43	6.19		
	Sergeant First Class	6	48.33	5.43		
	Major or higher	7	49.00	8.93		

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

4.5. Military Rank and Pinch Strength of Professional Occupation Soldiers

We looked into the pinch strength of professional soldiers by rank. There was no statistical difference in the right and left hands' grip strength by military rank. The results are shown in Table 6

Table 6.
Military rank and grip strength.

(N: 52, Unit: Kg)

	Rank	N	Mean	SD	F	P
Right hand	Corporal	5	10.40	2.07	0.345	0.846
	Sergeant	20	9.79	1.58		
	Staff Sergeant	14	9.67	1.58		
	Sergeant First Class	6	9.83	0.98		
	Major or higher	7	10.42	1.69		
Left hand	Corporal	5	9.40	2.30	0.848	0.504
	Sergeant	20	10.21	2.01		
	Staff Sergeant	14	9.33	1.58		
	Sergeant First Class	6	9.33	1.03		
	Major or higher	7	10.67	1.63		

5. Discussion

This study compared the grip strength of military personnel and male civilians. The results clearly demonstrate that military personnel exhibit significantly higher grip strength compared to their civilian counterparts. This finding supports the hypothesis that structured and systematic physical training, characteristic of military programs, has a direct and beneficial impact on grip strength. The observed difference in mean grip strength between the groups indicates potential physiological adaptations that result from rigorous training regimes [6].

Similar results were reported in a recent study, which found a positive association between grip strength and upper body power among military personnel [15]. This study highlights the functional importance of grip strength within military contexts, reinforcing that physical training programs focused on strength development contribute to enhanced combat preparedness. This supports the present study's conclusion that systematic physical conditioning in the military setting not only improves grip strength but also strengthens overall physical readiness.

5.1. Hypothesis 1: Differences in Grip Strength Between Professional Soldiers and Ordinary Citizens

In this study, grip strength was measured using the Jamar® Hydraulic Hand Dynamometer, a device widely recognized for its reliability and validity in clinical evaluation [13]. The grip strength of soldiers was higher among military and civilian participants. These substantial differences not only highlight the effectiveness of regular physical training in the military but also suggest that these systematic programs have a marked effect on improving physical performance.

The significant grip strength observed in military personnel indicates enhanced muscular performance and broader implications for overall health. Studies have shown that higher grip strength is associated with lower risks of cardiovascular disease, improved bone density, and greater longevity [13]. The findings suggest that the physical training regimens used in the military could benefit civilian populations by improving health outcomes and reducing the risk of various chronic conditions. This is considered an essential condition for maintaining optimal combat power and condition.

Military training programs are designed to enhance various physical capacities, including strength, endurance, and agility. The superior grip strength observed in military personnel could be attributed to the comprehensive nature of their physical training, which consistently emphasizes the development of muscle strength and endurance. This study reinforces the importance of regular and structured physical activity in achieving higher levels of physical fitness, which is particularly evident in the military's systematic approach to training. Although no prior measurements were taken in the case of soldiers, the

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

training may affect grip strength.

5.2. Hypothesis 2: Grip Strength and Age of Professional Soldiers

In this study, it was found that there was no difference in grip strength by age among professional soldiers. However, in the case of the right hand, the grip strength of people in their 40s was higher than those in their 20s. An analysis stratifying the participants of Professional Occupation Soldiers by age groups (Due to the military's command system, it was impossible to recruit the same number of people by age group so that no statistical difference could be seen, but the average grip strength values were compared), while controlling for the training background, revealed that the decline in grip strength typically associated with aging appeared less pronounced among military personnel. In fact, grip strength was highest in people in their 40s, followed by people in their 20s and 30s. This observation suggests that continuous physical training may mitigate age-related losses in muscle strength and functionality.

Grip strength is sensitive to age-related and biological function changes in the hand functions. Decreased grip strength is a feature of age-related muscle strength loss and can indicate overall health in older adults [16].

Grip strength is a key factor in performing many daily activities and is often taken as a proxy for general body strength. The ability to maintain higher levels of grip strength may aid in performing routine tasks, preventing injuries, and enhancing the quality of life. Therefore, integrating grip strength training into regular fitness routines could be advantageous for the general public, not just for athletes or military personnel. Although grip strength is not directly required to perform functional activities such as gait, it does distinguish between older adults based on their mobility [17].

5.3. Hypothesis 3: Difference in Grip Strength and Pinch Strength Between Military Ranks

This study showed no difference in grip and pinch strength by military rank. Therefore, it can be seen that there is no difference in grip strength and pinch strength due to rank. In general, as one's rank increases, one's age increases. Soldiers' systematic and continuous training helped them overcome aging of their muscles. Dynamometers perform quantitative measurements of maximum isometric muscle strength of the hand [18]. The grip measured in this study using dynamometers was the palmar grip. All the fingers perform palmar grip. The integrity of the digitorum superficial and profundus muscles and of the intrinsic muscles of the hand allows the performance of powerful flexion of the phalanges from the 2nd to 5th finger [19]. The pulp-to-paste pinch is performed between the thumb and index finger pulps, is used to seize small objects, and is the most delicate and precise digital pinch [20]. It is used in about 60% of the ADLs, such as picking a pen. It is a pinch of intermediate strength [21]. In this position, the superficial flexor muscle of the 2nd and 3rd fingers must stabilize the middle phalanges, and the thenar muscles must stabilize the proximal phalange of the thumb in flexion [18].

5.4. Limitations and Future Research

While this study provides valuable insights into the impact of military training on grip strength, there are limitations that should be addressed in future research. The study's cross-sectional design does not allow for causal inferences. Longitudinal studies would be beneficial in tracking changes in grip strength over time and better understanding the causality between specific training components and grip strength improvements. Additionally, replicating this study in diverse populations and settings could help generalize the findings. Due to the special status of the research subjects as soldiers, the number of people in each age group was not evenly distributed, and the number of research subjects needed to be increased. A detailed distinction between dominant and non-dominant hands was not made.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 5: 83-91, 2025
DOI: 10.55214/25768484.v9i5.6800

6. Conclusion

This study compared grip strength between military personnel and civilians to investigate the association between systematic training and grip strength outcomes. The results revealed that military personnel exhibited significantly higher grip strength than civilians (M = 50 kg for military vs. M = 47 kg for civilians), with a notable difference of 3 kg. This disparity suggests that the systematic training inherent in military programs likely has a positive impact on enhancing grip strength, showcasing the effective aspects of military training. The observed difference in grip strength implies that systematic training received by military personnel contributes to improving physical capabilities, particularly grip strength. Additionally, this study highlights the importance of continuous training in preventing the decline in grip strength associated with aging. The lower variability and maintenance of higher grip strength among military personnel suggest that systematic training can preserve physical capabilities over the long term. Pinch grip strength and agility are crucial in operational efficiency for military personnel. This type of grip is essential for precisely manipulating small objects such as weapons, tools, and other equipment. During military operations, tasks that require fine motor skills, such as assembling small parts or handling explosives, are frequently necessary. Regular training in pinch grip prepares soldiers to perform these critical tasks effectively, enhancing their overall mission performance capabilities and ensuring efficient use of equipment in combat and non-combat situations. The study also observed that grip strength was highest in individuals in their 40s, followed by those in their 30s and 20s, emphasizing the inclusion or need for pinch grip strength enhancement in military physical training programs. These findings reaffirm the importance of grip strength in daily life and professional tasks, suggesting that integrating systematic grip strength training into civilian fitness programs could be beneficial. Additionally, grip strength is an important indicator for maintaining a healthy lifestyle and preventing functional decline during aging. In conclusion, this study provides critical insights into the physical health assessments and training program designs for military and civilian populations. Future research should longitudinally track grip strength changes across a more diverse group of individuals to clarify the causes of these variations more distinctly.

Funding:

This research was conducted as a project for Sehan University in 2025.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

References

[1] R. W. Bohannon, "Reference values for adult grip strength measured with a Jamar dynamometer: A descriptive meta-analysis," *Physiotherapy*, vol. 91, no. 2, pp. 102-109, 2005. https://doi.org/10.1016/j.physio.2004.11.007

[2] C. D. Metcalf, T. A. Irvine, J. L. Sims, Y. L. Wang, A. W. Su, and D. O. Norris, "Complex hand dexterity: A review of biomechanical methods for measuring musical performance," *Frontiers in Psychology*, vol. 5, p. 414, 2014. https://doi.org/10.3389/fpsyg.2014.00414

[3] T. Rantanen, K. Avlund, H. Suominen, M. Schroll, K. Frändin, and E. Pertti, "Muscle strength as a predictor of onset of ADL dependence in people aged 75 years," *Aging Clinical and Experimental Research*, vol. 14, no. 3 Suppl, pp. 10-15, 2002. https://doi.org/10.1007/BF03324546

[4] J. Fernandez-Fernandez, L. M. Gallo-Salazar, and A. Moya-Ramon, "The effect of strength training on performance in endurance athletes " *Sports Medicine*, vol. 48, no. 4, pp. 845-865, 2018. https://doi.org/10.1007/s40279-018-0872-z

[5] K. S. Beyer, A. Fukuda, and D. H. Boone, "The role of strength training in injury prevention and performance in tennis," *Journal of Sports Sciences*, vol. 29, no. 12, pp. 1233-1241, 2011. https://doi.org/10.1080/02640414.2011.587446

[6] D. W. Keeley, J. Oliver, and R. Dougherty, "Strength training in the U.S. Army: Past, present, and future " *Strength & Conditioning Journal*, vol. 32, no. 2, pp. 55-64, 2010. https://doi.org/10.1519/SSC.0b013e3181d5265d

[7] B. E. Heilbronn, K. Doma, D. Gormann, M. Schumann, and W. H. Sinclair, "Effects of periodized vs. non periodized resistance training on army-specific fitness and skills performance," *Journal of Strength and Conditioning Research*, vol. 34, no. 2, pp. 738-753, 2020.

[8] K. M. Heinrich, V. Spencer, N. Fehl, and W. S. Carlos Poston, "Mission essential fitness: comparison of functional circuit training to traditional Army physical training for active duty military," *Military Medicine*, vol. 177, no. 10, pp. 1125-1130, 2012.

[9] P. T. Nikolaidis, K.-G. Papaioannou, T. Rosemann, and B. Knechtle, "Exercise testing of muscle strength in military," *Military Medicine*, vol. 184, no. 9-10, pp. e426-e430, 2019.

[10] J. R. Whitehead, "Fitness assessment results—some concepts and analogies," *Journal of Physical Education, Recreation & Dance*, vol. 60, no. 6, pp. 39-43, 1989. https://doi.org/10.1080/07303084.1989.10609947

[11] M. E. Lester, M. A. Sharp, W. C. Werling, L. A. Walker, B. S. Cohen, and T. M. Ruediger, "Effect of specific short-term physical training on fitness measures in conditioned men," *The Journal of Strength & Conditioning Research*, vol. 28, no. 3, pp. 679-688, 2014. https://doi.org/10.1016/j.jsams.2017.06.012

[12] A. Garcia-Hermoso, M. Cavero-Redondo, and B. Ramirez-Velez, "Is muscle strength a predictor of long-term physical function in older adults?," *Journal of Science and Medicine in Sport*, vol. 21, no. 4, pp. 334-339, 2018.

[13] D. P. Leong *et al.*, "Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study," *The Lancet*, vol. 386, no. 9990, pp. 266-273, 2015. https://doi.org/10.1016/S0140-6736(14)62000-6

[14] R. E. Smalley and C. D. Scott, "Advancements in handgrip strength: Techniques and applications," *Journal of Biomechanics*, vol. 71, pp. 139-145, 2018. https://doi.org/10.1016/j.jbiomech.2018.02.010

[15] A. Silder, R. Zifchock, L. Brown, P. Sessoms, and D. Jones, "The association between grip strength, upper body power, and limb dominance in a military population," *Military Medicine*, vol. 189, no. 9-10, pp. e1846–e1850, 2024.

[16] S. Namkoong and H. Roh, "Function of the hand as a predictor of early diagnosis and progression of Alzheimer's dementia: A systematic review," *Technology and Health Care*, vol. 32, pp. S253-S264, 2024. https://doi.org/10.3233/THC-248022

[17] R. W. Bohannon, "Grip strength: An indispensable biomarker for older adults," *Clinical Interventions in Aging*, vol. 14, pp. 1681-1691, 2019. https://doi.org/10.2147/CIA.S194543

[18] A. C. d. C. Ferreira, A. C. Shimano, N. Mazzer, C. H. Barbieri, V. M. C. Elui, and M. d. C. R. Fonseca, "Grip and pinch strength in healthy children and adolescents," *Acta Ortopédica Brasileira*, vol. 19, no. 2, pp. 92-97, 2011.

[19] E. B. Caetano, *Functional anatomy of the hand. In Pardini Júnior, A. G. (Ed.), Hand injuries*. Medsi, 2000.

[20] I. M. Abdalla and M. C. Brandão, *Palmar grip and digital pinch strengths. In Brazilian Society of Hand Therapists (Ed.), Recommendations for evaluation of the upper limb*, 2nd ed. São Paulo: SBTM, 2005.

[21] A. I. Kapandji, *The hand. In Pacheco da Costaa, S. (Ed.), Fisiologia articular: Annotated diagrams of human mechanics*, 5th ed. São Paulo: Panamericana, 2000.