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Association Between Body Mass Index and Handgrip Strength in Manual Handling Workers

Rindha Puji Rahayuningrum*, Fajar Syamsudin
Universitas Negeri Semarang, Indonesia
Email: rindarinn31@gmail.com*, fajarsyamsudin96@gmail.com

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Abstract
Nutritional status significantly influences workers' physical capacity, particularly muscle strength required for manual handling activities. This study aimed to evaluate the distribution of body mass index (BMI) and handgrip strength and to determine their association among manual handling workers at CV. Laksana Es Kristal. This cross-sectional correlational study involved 20 respondents selected through purposive sampling. Body mass index was assessed using height and weight measurements, while handgrip strength was measured using a handgrip dynamometer. Data were analyzed using the Spearman correlation test. The findings showed that the mean BMI was 20.22 kg/m², with 70% of respondents classified as having a normal BMI category. The mean handgrip strength was 40.12 kg, with most respondents categorized as having moderate strength. Statistical analysis revealed a significant positive association between BMI and handgrip strength ($p = 0.041$; $r = 0.46$), indicating a moderate correlation. Workers with optimal nutritional status demonstrated greater muscle strength. These findings suggest that BMI contributes to variations in physical work capacity, although muscle strength is also influenced by other physiological and occupational factors. This study highlights the importance of integrating nutritional monitoring and physical fitness management into occupational health programs to support workers' functional performance and reduce musculoskeletal risks.

INTRODUCTION

Occupational safety and health have become major global concerns because they are closely associated with workforce productivity, work sustainability, and the prevention of occupational diseases. Industrial sectors involving physically demanding activities continue to report high rates of work-related musculoskeletal disorders, particularly among workers performing repetitive manual handling tasks (BGS, 2024). Manual handling activities, such as lifting, carrying, and transporting loads, require adequate muscular strength and physical endurance to maintain safe and efficient work performance. Inadequate physical capacity may increase the risk of cumulative fatigue, musculoskeletal injuries, reduced concentration, and decreased productivity in industrial settings (Mulyadi, 2020; Priyanto, 2022).

Workers' physical capacity is influenced by multiple physiological factors, including nutritional status and body composition. Body mass index (BMI) is one of the most widely used anthropometric indicators for assessing nutritional status and general physical condition (Dessritina, 2024). BMI provides a practical representation of the relationship between body weight and height and is frequently used in occupational and clinical assessments due to its simplicity and low implementation cost. Previous studies have suggested that abnormal BMI values may negatively affect muscular performance. Individuals with low BMI often

demonstrate insufficient muscle mass, whereas excessive BMI may indicate increased fat accumulation that reduces movement efficiency and increases mechanical stress on the musculoskeletal system (Lafontant et al., 2023; Chapelon et al., 2025). Studies have further indicated that body composition significantly influences muscle function, physical performance, and occupational capacity (Anderson et al., 2024; Tou et al., 2022).

Handgrip strength is recognized as an objective indicator of upper-extremity muscle strength and overall functional capacity. Handgrip strength assessment is widely applied in occupational health and clinical settings because it provides rapid, practical, and quantitative measurements of muscular performance (Borges et al., 2025). Previous evidence has demonstrated that handgrip strength correlates with overall muscle strength, physical fitness, and work capacity, making it an important parameter for evaluating workers exposed to physically demanding occupations (Wen et al., 2023; Shafiee et al., 2024). Furthermore, reduced handgrip strength has been associated with an increased risk of fatigue, work limitations, and musculoskeletal disorders (Ormaza et al., 2024).

The relationship between BMI and handgrip strength can be explained through work capacity theory and body composition theory. Work capacity theory emphasizes that physical performance depends on the balance between occupational workload and physiological capacity, including musculoskeletal, cardiovascular, and metabolic functions. Meanwhile, body composition theory suggests that the proportion of muscle mass and fat mass directly affects force production efficiency and physical performance. Balanced body composition contributes to optimal muscular contraction and efficient energy utilization, whereas disproportionate fat accumulation may impair movement efficiency and accelerate fatigue (Singh & Shukla, 2024; Maluf et al., 2023).

Several previous studies have investigated the association between BMI and handgrip strength in different populations. Research among university students and athletes demonstrated that individuals with more optimal nutritional status generally exhibited greater muscular strength (Paul & Srinivas, 2020; Rahmadi & Anjani, 2024). Other studies have reported that lean mass and body composition mediate the relationship between BMI and muscle performance (Bim et al., 2023). However, findings across studies remain inconsistent. Research involving older adults has indicated weaker or non-significant associations due to age-related physiological changes, such as sarcopenia and declining muscle quality (Soraya & Parwanto, 2023; Siregar et al., 2024). In addition, physical activity levels and occupational demands may influence the relationship between BMI and muscular strength, indicating that interactions among these variables are multifactorial and population-specific (Nam et al., 2025; Sampaio et al., 2025).

Despite growing evidence regarding BMI and muscular strength, most studies in Indonesia have primarily focused on students, athletes, and older adults. Research involving manual handling workers remains limited, particularly in small- and medium-scale industrial settings. This represents an important research gap because manual handling workers are continuously exposed to repetitive physical workloads requiring adequate musculoskeletal capacity (Bankar, 2021; Ghosh & Sarkar, 2024). Insufficient physical condition among these workers may contribute to occupational fatigue, decreased productivity, and an increased risk of musculoskeletal injuries (Svartengren, 2025).

The urgency of this research lies in the need to provide empirical evidence regarding the association between nutritional status and muscular strength among manual handling workers, which can support evidence-based occupational health policies. Given the increasing recognition of musculoskeletal disorders (MSDs) as a major occupational health burden, understanding the factors influencing workers' physical capacity is essential for designing effective preventive interventions. The novelty of this study lies in its specific focus on manual handling workers in a small- and medium-scale industrial setting in Indonesia, an occupational group that has received limited attention in previous research. Furthermore, this study integrates anthropometric measurements and muscular strength assessments to provide a comprehensive evaluation of workers' physical fitness (Coge et al. 2024; Ras et al. 2024).

CV. Laksana Es Kristal is an industrial workplace where operational activities involve repetitive lifting, carrying, and transporting processes during ice production and distribution. These activities require adequate handgrip strength and physical capacity to maintain work efficiency and safety. However, no previous study has specifically examined the association between BMI and handgrip strength among workers in this occupational setting. The lack of empirical evidence limits the development of targeted occupational health interventions and worker fitness management programs.

Therefore, this study aimed to evaluate the characteristics of BMI and handgrip strength and examine the association between these two variables among manual handling workers at CV. Laksana Es Kristal. The findings are expected to contribute theoretically to the understanding of anthropometric characteristics and muscular performance in physically demanding occupations and practically support evidence-based occupational health management programs.

METHOD

This study employed a quantitative approach with an analytical observational design using a cross-sectional method. The study aimed to examine the association between body mass index (BMI) and handgrip strength through numerical measurements and statistical analysis. The cross-sectional design allowed both variables to be measured simultaneously at a single point in time without researcher intervention. This design was appropriate for assessing the association between nutritional status and muscular strength among manual handling workers (Sugiyono, 2021; Sundari & Utaya, 2023).

The study was conducted at CV. Laksana Es Kristal, an industrial workplace where workers routinely performed manual handling activities involving lifting and transporting loads. The study population consisted of all manual handling workers employed at CV. Laksana Es Kristal. The sample included workers who met the eligibility criteria and agreed to participate. A total sampling technique was applied, in which all eligible workers were recruited as respondents to maximize population representation (Sugiyono, 2020).

The independent variable was BMI, representing workers' nutritional status, while the dependent variable was handgrip strength, reflecting upper-extremity muscle strength and physical work capacity. Body weight was measured using a calibrated weighing scale, and body height was measured using a microtoise or stadiometer. BMI was calculated using the standard anthropometric formula. Handgrip strength was measured using a handgrip

dynamometer to assess muscular strength among workers performing manual handling activities (Nurhadi, 2024; Handayani, 2025).

Data were collected through direct anthropometric measurements and handgrip strength assessments using standardized instruments and procedures. Respondent characteristics were documented to support descriptive analysis. All measurements were performed consistently according to standardized operational procedures to maintain data accuracy, validity, and reliability (Fatchan, 2022).

The collected data were analyzed using descriptive and inferential statistical methods. Descriptive analysis was used to present the distribution of respondent characteristics, BMI, and handgrip strength. Data distribution was assessed before inferential testing to determine the appropriate statistical method. The association between BMI and handgrip strength was analyzed using the Spearman correlation test because the data did not meet normality assumptions. Statistical significance was determined at $p < 0.05$ (Priyanto Wijaya, 2021, 2023).

RESULTS AND DISCUSSION

The study was conducted at CV. Laksana Es Kristal after obtaining administrative authorization from the company and research approval procedures. Data collection was carried out from January 10 to January 15, 2026, involving all manual handling workers who fulfilled the inclusion criteria and agreed to participate as respondents. The duration of the study implementation was five days. This section presents the findings regarding respondent characteristics, Body Mass Index (BMI), handgrip strength, and the correlation analysis between both variables. Each finding is directly followed by an integrated discussion to provide comprehensive interpretation and scientific contextualization.

Distribution of Body Mass Index

The analysis showed that the mean body mass index of respondents was 20.22 kg/m², with the majority classified within the normal body mass index category (70%). These findings indicate that most workers possessed relatively balanced nutritional status according to standard anthropometric classification.

Table 1. Distribution of Body Mass Index Among Respondents

BMI Category	Frequency (%)
Underweight	20,0%
Normal	70,0%
Overweight	5,0%
Obesity Class I	5,0%
Obesity Class II	0,0%
Total	**100,0%**

The predominance of normal body mass index among workers suggests that most respondents had relatively proportional body composition, characterized by an optimal balance between muscle mass and adipose tissue that supports functional movement efficiency. Adequate nutritional status plays an important role in supporting physical work capacity because balanced body composition contributes to efficient muscle contraction, optimal energy

utilization during occupational activities, and reduced metabolic strain during prolonged physical exertion (Dessritina, 2024). Normal body mass index reflects not only appropriate energy balance but also adequate protein intake and micronutrient availability, which are essential for maintaining muscle integrity, neuromuscular coordination, and cardiovascular endurance in physically demanding work environments such as manual handling. Previous studies have also demonstrated that normal body mass index is generally associated with better physical fitness, superior muscular performance, greater work productivity, and lower injury risk compared with underweight or overweight conditions, particularly in occupations requiring repetitive lifting, carrying, and load manipulation (Bim et al., 2023; Lafontant et al., 2023). Workers with abnormal body mass index, whether underweight or overweight, may experience decreased movement efficiency, accelerated fatigue, impaired work performance, and increased susceptibility to musculoskeletal disorders due to disproportionate body composition, altered center of gravity, increased biomechanical burden on joints and soft tissues, and compromised cardiorespiratory capacity during sustained physical tasks (Anderson et al., 2024). Furthermore, deviations from normal body mass index can adversely affect postural stability, dynamic balance, and force generation capacity, all of which are critical for safe and effective execution of manual handling tasks in occupational settings.

Distribution of Handgrip Strength

The results further demonstrated that the mean handgrip strength among respondents was 40.12 kg and was predominantly categorized as moderate. These findings indicate that most workers possessed adequate upper-extremity muscular strength to support manual handling activities performed routinely within the workplace.

Table 2. Distribution of Handgrip Strength Among Respondents

Handgrip Strength	Percentage (%)
10 – 19,9	0%
20 – 29,9	15,0%
30 – 39,9	50,0%
40 – 49,9	20,0%
50 – 59,9	5,0%
60 – 69,9	10,0%
Total	**100,0%**

Handgrip strength reflects overall muscular performance and functional work capacity, particularly among workers exposed to repetitive physical activities, and serves as a reliable proxy for upper extremity strength, neuromuscular coordination, and whole-body physical fitness (Wen et al., 2023). Adequate grip strength is essential for maintaining effective load control, sustaining ergonomic posture throughout work shifts, preventing accidental load release, and ensuring occupational safety during manual handling processes that require sustained gripping, lifting, carrying, and precise object manipulation. Beyond its biomechanical role, handgrip strength is closely associated with cardiovascular health, bone density, nutritional adequacy, and metabolic function, making it a multidimensional indicator of overall worker health and resilience in physically demanding occupations. Previous studies

have consistently reported that workers with lower grip strength are more likely to experience chronic musculoskeletal complaints, particularly in the hands, wrists, shoulders, and lower back, as well as accelerated work fatigue, reduced task efficiency, increased absenteeism, and decreased productivity due to compensatory movement patterns, prolonged task completion times, and diminished capacity to meet physical job demands (Ormaza et al., 2024). Workers with compromised grip strength may also adopt maladaptive postures or excessive muscular co-contraction to compensate for inadequate force generation, thereby increasing the mechanical stress on joints and soft tissues and elevating the risk of cumulative trauma disorders. In occupational settings, handgrip strength assessment may therefore serve as a practical, cost-effective, and non-invasive indicator for monitoring workers' physical fitness, evaluating the effectiveness of workplace health interventions, identifying individuals at greater risk of work-related injury or functional decline, and guiding targeted ergonomic modifications or individualized fitness training programs to enhance worker safety and long-term occupational well-being.

Association Between Body Mass Index and Handgrip Strength

The correlation analysis revealed a significant positive association between body mass index and handgrip strength among manual handling workers at CV. Laksana Es Kristal ($p = 0.041$; $r = 0.46$). The correlation coefficient indicated a moderate relationship, suggesting that workers with more optimal nutritional status tended to demonstrate greater handgrip strength.

Table 3. Association Between Body Mass Index and Handgrip Strength

Variable	Correlation Coefficient	Sig. (2-tailed)	N
BMI ↔ Handgrip Strength	0,46	0,041	20

These findings support the theoretical perspective that nutritional status, as reflected by body mass index, contributes significantly to muscular performance, neuromuscular efficiency, and overall physical work capacity through its influence on body composition, metabolic function, and biomechanical efficiency. Balanced body composition, characterized by adequate lean muscle mass and proportional fat distribution, allows for more efficient energy conversion into mechanical force by optimizing ATP availability, enhancing calcium handling within muscle fibers, reducing unnecessary metabolic load, and minimizing biomechanical inefficiencies associated with excessive adipose tissue, thereby improving muscle contraction efficiency, force production, and endurance capacity during physically demanding tasks such as manual handling (Maluf et al., 2023). Furthermore, optimal body mass index is associated with better mitochondrial function, improved oxygen delivery to working muscles, and enhanced neuromuscular activation patterns, all of which contribute to superior functional performance in occupational settings. The results are consistent with previous studies reporting significant positive associations between body mass index and handgrip strength among adult populations, physically active individuals, and workers engaged in repetitive manual tasks, suggesting that the relationship between nutritional status and muscular strength is robust

across diverse demographic groups and activity levels (Paul & Srinivas, 2020; Rahmadi & Anjani, 2024). Similarly, Bim et al. (2023) reported that lean mass and fat mass mediate the relationship between body mass index and muscular strength, with lean mass demonstrating a strong positive effect on grip strength while excessive fat mass may introduce biomechanical disadvantages, indicating that body composition—rather than body mass index alone—plays an important and nuanced role in determining functional performance, movement efficiency, and occupational physical capacity. These findings underscore the importance of considering not only overall body mass but also the quality of tissue composition when evaluating workers' physical readiness and designing targeted nutritional and exercise interventions to optimize occupational health outcomes.

However, the moderate strength of correlation observed in this study suggests that body mass index is not the sole determinant of muscular strength and that the relationship between nutritional status and physical capacity is multifactorial and context-dependent. Other factors such as habitual physical activity level, cumulative occupational workload exposure, progressive neuromuscular adaptation resulting from repetitive manual tasks, chronological and biological age, genetic predisposition, muscle fiber type distribution, muscle quality as reflected by intramuscular fat infiltration and connective tissue density, hormonal status including testosterone and growth hormone levels, sleep quality, psychosocial stress, and overall health status may also substantially influence handgrip strength performance and functional work capacity (Nam et al., 2025; Sampaio et al., 2025). For instance, workers who engage in regular physical exercise outside of work may develop superior muscular strength despite having similar body mass index values compared to sedentary workers, illustrating the importance of lifestyle factors beyond static anthropometric measures. This finding is further supported by studies demonstrating inconsistent and sometimes paradoxical relationships between body mass index and muscular strength across different populations, particularly among older adults experiencing sarcopenia, age-related muscle atrophy, declining motor unit function, and progressive physiological decline characterized by reduced protein synthesis, impaired neuromuscular transmission, and increased systemic inflammation, all of which can decouple the expected association between body mass and strength (Soraya & Parwanto, 2023). These observations highlight the complexity of the body mass index–muscle strength relationship and underscore the need for comprehensive assessments that consider body composition, functional capacity, and occupational context when evaluating workers' physical readiness.

From an occupational health perspective, the findings emphasize the critical importance of integrating comprehensive nutritional monitoring, individualized physical fitness management, and proactive ergonomic interventions into workplace health programs to optimize worker well-being and organizational productivity. Regular and systematic assessment of body mass index, handgrip strength, body composition analysis, and functional movement screening may assist companies in identifying workers at elevated risk of declining physical capacity, chronic fatigue, reduced work tolerance, and work-related musculoskeletal disorders before clinical symptoms emerge, thereby enabling timely preventive action and targeted support. Preventive interventions such as evidence-based nutritional improvement programs tailored to workers' energy expenditure and metabolic needs, structured physical exercise regimens including resistance training and functional conditioning, ergonomic

workload adjustment through job rotation and task redesign, workplace wellness initiatives promoting healthy lifestyle behaviors, and periodic health monitoring with feedback and follow-up may therefore contribute significantly to maintaining optimal work productivity, enhancing worker resilience and recovery capacity, reducing absenteeism and presenteeism, preventing long-term disability, and minimizing occupational injury risks among manual handling workers. Furthermore, fostering a workplace culture that prioritizes physical health, provides accessible fitness resources, and encourages active employee participation in wellness programs can yield long-term benefits including improved morale, reduced healthcare costs, enhanced organizational reputation, and sustained competitive advantage in physically demanding industries.

CONCLUSION

This study demonstrated that the majority of manual handling workers at CV. Laksana Es Kristal had body mass index (BMI) values within the normal category and moderate levels of handgrip strength. The findings further revealed a significant positive association between BMI and handgrip strength, indicating that workers with more optimal nutritional status tended to exhibit greater muscular strength. The moderate correlation observed in this study suggests that nutritional status contributes to physical work capacity, particularly upper-extremity muscle performance required for manual handling activities. However, BMI was not the sole determinant of muscular strength, as physical performance may also be influenced by other physiological and occupational factors, including physical activity level, workload, muscle quality, and work adaptation. Overall, these findings provide empirical evidence supporting the importance of maintaining balanced nutritional status and adequate physical capacity among workers engaged in physically demanding occupations.

REFERENCES

Anderson, G., Garcia, C. J., Sweed, T., & Medler, S. (2024). Measuring body composition and functional strength: Implications for the clinical assessment of skeletal muscle. *Physiology*. https://doi.org/10.1152/physiol.2024.39.s1.385

Bankar, A. W. (2021). Ergonomic evaluation and risk management of manual material handling activities. *9*(2), 1045–1050. https://doi.org/10.17762/ITII.V9I2.450

Bim, M. A., de Pinto, A., Claumann, G. S., & Pelegrini, A. (2023). Mediation effects of lean mass and fat mass on the relationship between body mass index and handgrip strength. *American Journal of Human Biology, 36*(4). https://doi.org/10.1002/ajhb.24004

Borges, R. C. de S., Bocchi, M., Freitas, J. C., Silva, A. K. A. C., Gouvêa-e-Silva, L. F., de Oliveira, D. M., & Fernandes, E. V. (2025). Use of handgrip strength as a health indicator in public sector workers: A cross-sectional study. *Journal of Functional Morphology and Kinesiology, 10*(2), 1–12. https://doi.org/10.3390/jfmk10020135

Chapelon, J., Sourdet, S., Angioni, D., Steinmeyer, Z., Briand, M., Rolland, Y., & Van Kan, G. A. (2025). Body composition of older adults with normal body mass index: Cross-sectional analysis of the Toulouse Frailty Clinic. *The Journal of Frailty & Aging, 14*(1), Article 100003. https://doi.org/10.1016/j.tjfa.2024.100003

Coge, M., et al. (2024). Effects of 34 weeks of military service on body composition and physical fitness in military cadets of Angola. *Journal of Functional Morphology and Kinesiology, 9*(3), Article 111.

Dessritina, P. (2024). The relationship between nutritional status and physical performance of workers and sports athletes: A literature review. *PENAMEDIKA: Jurnal Kesehatan, 14*,

504–515.
Fatchan, A. (2022). *Metodologi penelitian: Kuantitatif, kualitatif, dan mixed method*. UIN Press.
Ghosh, S., & Sarkar, K. (2024). An ergonomic approach to sustainability for the manual material handling workers: A review, 246–256. https://doi.org/10.52756/boesd.2024.e03.017
Handayani, R. (2025). *Pengantar riset kesehatan*. Salemba Medika.
Lafontant, K., Thiamwong, L., Stout, J. R., Park, J., Xie, R., & Fukuda, D. H. (2023). Redefining obesity: A ratio of fat and muscle mass compared to body mass index in older adults. *Innovation in Aging*. https://doi.org/10.1093/geroni/igad104.3560
Maluf, V. A. B., Karsegard, V., Collet, T. H., Dupertuis, Y. M., & Genton, L. (2023). Relationship between body composition and hand grip strength in the general population. *Clinical Nutrition ESPEN*, 424–750. https://doi.org/10.1016/j.clnesp.2023.09.854
Mulyadi. (2020). *Ergonomi dasar untuk kesehatan kerja*. Gadjah Mada University Press.
Nam, H. K., Jang, S. N., Kawachi, I., Ma, Y., & Cho, S. I. (2025). Association between physical activity and handgrip strength among older adults in the Korean Longitudinal Study of Ageing. *Scientific Reports, 15*(1). https://doi.org/10.1038/s41598-025-29619-6
Nurhadi. (2024). *Pengukuran dan evaluasi dalam pendidikan & ilmu sosial*. Kencana.
Ormaza, G. N. M., Vinueza, G. A., Solano, S. N., & Cabascango, K. E. (2024). Influence of grip strength and the onset of musculoskeletal disorders in professional drivers in Ibarra and Chone, 2024. *South Eastern European Journal of Public Health*, 797–806.
Paul, J., & Srinivas, A. (2020). Association between BMI and hand grip strength in university level cricket players. *International Journal of Medical and Exercise Science, 6*(April), 732–739. https://doi.org/10.36678/ijmaes.2020.v06i02.002
Priyanto, A. (2022). *Kesehatan dan keselamatan kerja: Pendekatan praktis*. Mitra Wacana Media.
Priyanto, D. (2021). *Statistik penelitian pendidikan dan sosial*. Prenadamedia Group.
Rahmadi, D., & Anjani, K. T. (2024). Korelasi indeks massa tubuh dengan kekuatan genggaman tangan pada mahasiswa Fakultas Kedokteran Universitas Baiturrahmah. *Nusantara Hasana Journal, 1*(7), 132–137.
Ras, J., et al. (2024). Evaluation of the relationship between occupational-specific task performance and measures of physical fitness, cardiovascular and musculoskeletal health in firefighters. *BMC Public Health, 24*(1), Article 20.
Sampaio, T., Oliveira, J. P., Magalhães, P. M., Bragada, J. A., Bartolomeu, R. F., Vasques, C., & Morais, J. E. (2025). Physical fitness and physical activity in young adults: A comparative study between two higher education institutions. *Journal of Functional Morphology and Kinesiology, 11*(1), Article 22. https://doi.org/10.3390/jfmk11010022
Shafiee, M. N. I., Zein, R. M., Tan, G. L., Baruji, M. E., Zubir, S. N., Salim, N., Rahman, S. Z., & Hamadan, H. A. (2024). Handgrip strength of Malaysian working-age population. In *Springer International Publishing* (pp. 3–15). https://doi.org/10.1007/978-3-031-60863-6_1
Singh, A., & Shukla, A. (2024). Co-relation between grip strength and body composition variables. https://doi.org/10.5281/zenodo.11581594
Soraya, N., & Parwanto, E. (2023). The controversial relationship between body mass index and handgrip strength in the elderly: An overview. *Malaysian Journal of Medical Sciences, 30*(3), 73–83. https://doi.org/10.21315/mjms2023.30.3.6
Sugiyono. (2020). *Metode penelitian pendidikan: Kuantitatif, kualitatif, dan R&D*. Alfabeta.
Sugiyono. (2021). *Metodologi penelitian kuantitatif: Teori dan aplikasi*. Alfabeta.
Sundari, S., & Utaya, S. (2023). *Metode penelitian kuantitatif di bidang kesehatan*. Nuha

Medika.
Svartengren, M. (2025). From strain to strength: Reducing musculoskeletal complaints in ironworkers through integration of physical training within work rotations. https://doi.org/10.3205/25premus078
Tou, N. X., Wee, S. L., Pang, B. W. J., Lau, L. K., & Jabbar, K. A. (2022). Association of fat mass index versus appendicular lean mass index with physical function: The Yishun Study. *Aging and Health Research, 2*(3), Article 100097. https://doi.org/10.1016/j.ahr.2022.100097
Wen, Z., Gu, J., Chen, R., Wang, Q., Ding, N., Meng, L., Wang, X., Liu, H., Sheng, Z., & Zheng, H. (2023). Handgrip strength and muscle quality: Results from the National Health and Nutrition Examination Survey database. *Journal of Clinical Medicine, 12*(9), 1–13. https://doi.org/10.3390/jcm12093184
Wijaya, I. (2023). *Statistik pendidikan dan sosial: Teori dan aplikasi dengan SPSS*. Rajawali Pers.