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Hand Grip Strength Profiles in Traditional Sumatran Communities: Demographic and Regional Influences

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ABSTRACT

The hand plays a vital role in performing daily tasks with precision, relying on the strength of the hand and forearm muscles. Hand grip strength is widely used as an indicator to assess upper limb muscle performance. Several factors, including daily activities, age, and sex, can influence grip strength. This study focuses on traditional Sumatran communities characterized by non-industrialized livelihoods and sustained manual labor, such as farming and plantation work. This provides a unique context for examining how a physically demanding lifestyle modulates natural trajectories of hand grip strength outside urban or clinical settings. This study aims to evaluate hand-grip strength in the Sumatran population. The research involved a literature review, obtaining informed consent, collecting demographic data, determining hand dominance, measuring grip strength using a dynamometer, conducting data analysis, and drawing conclusions. The results showed that peak hand grip strength for both males and females consistently occurred within the 20-29 age bracket. Significant differences were also found in right-hand grip strength. Linear model analysis revealed positive correlations with sex ($P = 2 \times 10^{-4}$), handedness ($P = 9.91 \times 10^{-6}$), income ($P = 0.039$), and specific regions: Central Lampung ($P = 0.01$), Way Kanan ($P = 1.86 \times 10^{-13}$), and Simalungun ($P = 0.01$). The influence of income and regionality likely reflects differences in nutritional access and the intensity of manual labor inherent in traditional agricultural hubs. In contrast, the starting hand for measurement, age (as a linear variable), and jobs that involve passive hand use do not affect hand grip strength.

1. Introduction

The hand is a vital functional appendage involved in performing a wide range of daily activities and tasks, many of which require gripping ability (Sukania *et al*. 2022). To function effectively, the hand must be able to control grip force when handling objects. The muscles of the upper extremity—including the hand, forearm, and upper arm—play an essential role in generating hand grip strength. In addition, daily activities that involve frequent hand use can influence the muscle mass of the hand and forearm. Measuring hand grip strength is widely recognized as a reliable method for assessing upper extremity muscle strength (Rosmalina *et al*. 2001; Setiawan & Setiowati 2014). Hand grip assessment is commonly performed using a handgrip dynamometer, a simple, non-invasive, and effective tool that provides an accurate depiction of grip strength (Saputra *et al*. 2016; Murdiyanti *et al*. 2018).

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Several factors are known to influence grip strength, including daily physical activity, age, and sex (Jakobsen *et al*. 2010; Purwitasari *et al*. 2020). However, most existing studies have been conducted in clinical or elderly populations, with limited research examining grip strength in Indonesian participants across demographic and occupational contexts. For instance, Negara *et al*. (2024) examined hand grip strength in relation to cognitive and metabolic function among older adults in Mengwi, Bali, while Vitriana and Defi (2020) investigated physical factors associated with performance decline among institutionalized elderly populations in West Java. Although such research is valuable for clinical geriatric care, it does not capture normative strength levels in broader adult populations, especially in traditional, non-clinical settings.

A recent review by Purwitasari *et al*. (2020) also highlighted the scarcity of normative grip-strength data for the general Indonesian population. This lack of representative, population-level data presents a significant gap in understanding natural variations in muscle strength across Indonesia's diverse cultural and occupational settings.

In this study, traditional communities are defined as semi-traditional rural populations in which farming and manual labor remain central to daily life, especially when compared to urbanized areas (Tantray & Mir 2021; Ramakrishnan 2001). Traditional Sumatran societies, where intensive hand use and manual activities are embedded in daily routines, offer a unique context for examining natural hand grip strength. Understanding grip strength in these communities may provide insight into how lifestyle, work type, and demographic variables affect physical capacity in populations outside clinical or athletic settings.

This study aimed to evaluate handgrip strength among individuals in selected rural regions of Sumatra and to explore how demographic factors, including handedness, age, sex, ethnicity, occupation, income, and residence, were associated with grip strength. The research was conducted across Central Lampung, South Lampung, Way Kanan, and Simalungun, using structured interviews, questionnaires, and objective measurements with a handgrip dynamometer. We hypothesized that the intensive manual workload embedded in traditional Sumatran lifestyles—beginning at an early age—would result in a distinct grip strength profile, in which peak strength is highly influenced by occupational demands rather than purely biological maturation.

2. Materials and Methods

2.1. Location

This study was conducted between July and August 2022 using a multi-site convenience sampling design. Data collection took place in two provinces: Lampung and North Sumatra. To capture diverse semi-traditional and agricultural contexts, specific regencies were chosen as study sites: Central Lampung, South Lampung, and Way Kanan Regencies in Lampung Province, and Simalungun Regency in North Sumatra. The selected regions are predominantly rural or semi-rural, where agricultural practices and manual labor remain common among residents. The participants included individuals from various ethnic backgrounds—primarily Lampungese, Javanese, and Batak—who represent semi-traditional communities in which daily work often involves manual labor, particularly in farming and plantation sectors. Data analysis was performed at the Biology Study Program, Faculty of Sciences, Institut Teknologi Sumatera.

2.2. Study Population and Sampling

The study employed a localized convenience sampling approach within the selected study sites, approaching groups of at least 2 individuals in public settings to ensure a witness was present during the informed consent process and the interview. This criterion was established as an ethical safeguard to ensure that participation was voluntary and that the study's objectives were communicated transparently. A total of 610 respondents participated, comprising 348 males and 262 females aged 14 to 87 years. For participants under the age of 16, recruitment was conducted exclusively in the presence of a parent or legal guardian who provided verbal informed consent alongside the minor's assent before the interview and measurements commenced. The sample size was determined using the Slovin formula, with a 6% margin of error. Based on the total population of Lampung Province (9,176,546) and Simalungun Regency (1,003,727), the minimum required sample size was 278 respondents from each region. The final sample exceeded this minimum, providing sufficient representation.

2.3. Data Collection

Demographic data were collected using structured questionnaires. Variables recorded included age, birth order, ethnicity, occupation, address, marital status,

income, handedness, and residence. Occupation was categorized to include formal employment, informal work, and student status. Hand grip strength was measured using a Camry EH101 dynamometer. The measurement protocol followed standardized physical assessment procedures. Participants were instructed to maintain a standing position with their shoulders adducted, neutral rotation, and the elbow fully extended. They were then asked to exert maximum gripping force on the dynamometer for three seconds. Measurements were performed bilaterally for both the right and left hands.

2.4. Research Procedure

This study received ethical approval from the Ethics Committee of the Faculty of Medicine, University of Lampung (Ethical Clearance No: 1594/UN26.18/PP.05.02.00/2023). Before participation, all respondents provided informed consent. For participants under 17 years of age (n = 14), recruitment was conducted exclusively in the presence of a parent or legal guardian. Formal verbal informed consent was obtained from the parents/guardians, along with the minor's assent, witnessed by at least 2 individuals in public settings, prior to the interviews and physical measurements. Participants completed demographic questionnaires, and handgrip strength was measured for both the right and left hands. Respondents could choose which hand to measure first.

Hand grip strength was assessed using the Camry EH101 dynamometer, a validated tool for measuring upper limb muscle strength (Saputra *et al*. 2016). During data collection, subjects maintained a standing posture with their elbows completely extended. Participants were prompted to exert maximal gripping force on the handle for at least 5 seconds, with consistent verbal encouragement from the researchers (Huang *et al*. 2022). Each participant performed one measurement for each hand. The difference in grip strength between hands, or called grip strength asymmetry, was calculated using the following formula:

$$\text{Asymmetry} = \frac{R - L}{R + L}$$

where *L* is the right-hand grip strength, and *R* is the left-hand grip strength. A positive result indicates greater strength in the right hand, while a negative result indicates greater strength in the left hand.

2.5. Data Analysis

Hand grip strength performance was analyzed in relation to demographic factors. For analytical purposes, participants' occupations were classified into two categories based on the intensity of hand muscle use involved in their daily work activities:

• High manual demand: occupations that require active, repetitive, and forceful use of the hand and forearm muscles, such as farming, construction work, and plantation labor.

• Low manual demand: occupations that involve minimal or passive hand use, typically for tasks such as writing, typing, or speaking, including students and employees.

This classification was developed based on direct fieldwork observations and self-reported descriptions of work activities. Although no standardized occupational physical-demand scale was used, this approach was intended to reflect real-world functional differences in manual workload.

To analyze the life-course trajectory of hand grip strength and mitigate potential variability or 'noise' associated with single-year age data, chronological age was categorized into seven distinct age groups: 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, and more than 70 years. Boxplots were used to show the distribution of hand grip strength within each category, with a mean trajectory line to identify the peak age group. A linear model was applied to assess the influence of demographic predictors, including sex, age, handedness, occupation, income, and residence, on hand grip strength. All statistical analyses were performed using R software version 4.3.1 (R Core Team 2023).

3. Results

3.1. Sociodemographic Characteristics

A total of 610 individuals—262 females and 348 males—took part in this study. Their ages ranged from 14 to 87 years, with a mean of 38 years. Participants from North Sumatra were recruited in Simalungun Regency, whereas those from Lampung Province were drawn from the regencies of South Lampung, Way Kanan, and Central Lampung. The sample represented several ethnic groups, including Javanese, Batak, Lampungese, and Sundanese. Most respondents reported working as farmers, traders, housewives, employees, or entrepreneurs. The sociodemographic details of the sample are summarized in the following table.

Table 1. Sociodemographic characteristics of respondents

Demography		n	%
Sex	Female	262	42.95
	Male	348	57.05
Age (Years)	Range	14 - 87	-
	Mean (SD)	38.61 (±15.02)	-
Province	North Sumatra (Simalungun)	302	49.51
	South Sumatra (Lampung Selatan, Way Kanan, Lampung Tengah)	308	50.49
Ethnicity	Javanese	254	41.64
	Batak	170	27.87
	Lampungese	103	16.89
	Sundanese	37	6.07
	Other	46	7.54
Occupation	Farmer	88	14.43
	Students	81	13.28
	Traditional trader	76	12.46
	Housewife	62	10.16
	Entrepreneur	55	9.02
	Employee	51	8.36
	Manual worker	26	4.26
	Other	171	28.03

3.2. Mean Hand Grip Strength

Across the entire study population (N = 610), the overall mean hand grip strength was 29.10 ± 11.15 for the right hand and 27.01 ± 11.38 for the left hand. The analysis revealed that the mean hand grip strength in both the right and left hands was higher in males compared to females. The mean right-hand grip strength in males was 34.99 ± 10.00 kg, while the left-hand grip strength was 33.28 ± 10.42 kg. In contrast, females exhibited a mean right-hand grip strength of 20.87 ± 4.75 kg and a left-hand grip strength of 18.62 ± 5.76 kg (Table 2).

Table 2. Mean hand grip strength by sex

Sex	Right hand (kg)	Left hand (kg)
All respondents	29.10 ± 11.15	27.01 ± 11.38
Male	34.99 ± 10.00	33.28 ± 10.42
Female	20.87 ± 4.75	18.62 ± 5.76

3.3. Factors Influencing Grip Strength Asymmetry

To evaluate the functional differences between an individual's hands, grip strength asymmetry was analyzed using the directional difference formula detailed in the methodology. The linear model analysis identified several factors significantly influencing grip strength asymmetry (Table 3). Sex was a significant predictor ($P = 2 \times 10^{-4}$), indicating that grip strength asymmetry was significantly more pronounced in females than in males. Handedness also had a significant effect ($P = 9.91 \times 10^{-6}$), suggesting that individuals who predominantly use their right hand tend to have stronger right-hand grip strength.

Income was positively associated with the difference in grip strength between hands (P = 0.039), suggesting occupational differences. Regional differences were also observed, with participants from Central Lampung (P = 0.01), Simalungun (P = 0.01), and Way Kanan ($P = 1.86 \times 10^{-13}$) showing greater grip strength asymmetry than those from South Lampung. The initial hand used for measurement did not significantly influence the grip strength asymmetry. While the linear model did not show age as a significant independent predictor of hand grip strength (P = 0.535), this is likely due to the non-linear nature of the age-related trajectory. As illustrated in Figure 1, grip strength follows a curvilinear pattern, increasing through adolescence to a peak in early adulthood (20-29 years) before gradually declining, a trend that is better captured through age-group categorization than a simple linear regression.

3.4. Peak Hand Grip Strength by Age and Sex

Analysis of age groups demonstrated that peak hand grip strength (HGS) consistently occurred within the 20-29 age bracket for both sexes and both hands (Figure 1). In females, the highest mean grip strength was observed in the 20-29 age group, followed by an increase from the 10-19 age category. Similarly, males reached their maximum mean HGS in the 20-29 age group, with measurements substantially higher than those of their female counterparts.

Following this peak decade, a progressive and gradual decline in hand grip strength was observed across all

Table 3. Linear model of variables influencing grip strength asymmetry

Variable	Estimate	Standard error	t-value	P-value
Intercept	-0.245	0.038	-6.427	$2.90 \times 10^{-10*}$
Sex (Female)	0.032	0.008	3.759	$2.00 \times 10^{-4*}$
Handedness (Right)	0.127	0.028	4.462	$9.91 \times 10^{-6*}$
Starting hand	0.022	0.030	0.746	0.455
Age	1×10^{-4}	1×10^{-4}	0.620	0.535
Income	0.004	0.002	2.064	0.04*
Central lampung	0.136	0.013	9.981	0.01*
Simalungun	0.113	0.010	10.775	0.01*
Way kanan	0.108	0.014	7.554	$1.86 \times 10^{-15*}$
Category LMD	0.004	0.007	0.605	0.54

*Significant at $p < 0.05$. "Starting hand" refers to the hand used first in the measurement. "Category LMD" refers to occupations with low manual demand that involve passive hand use

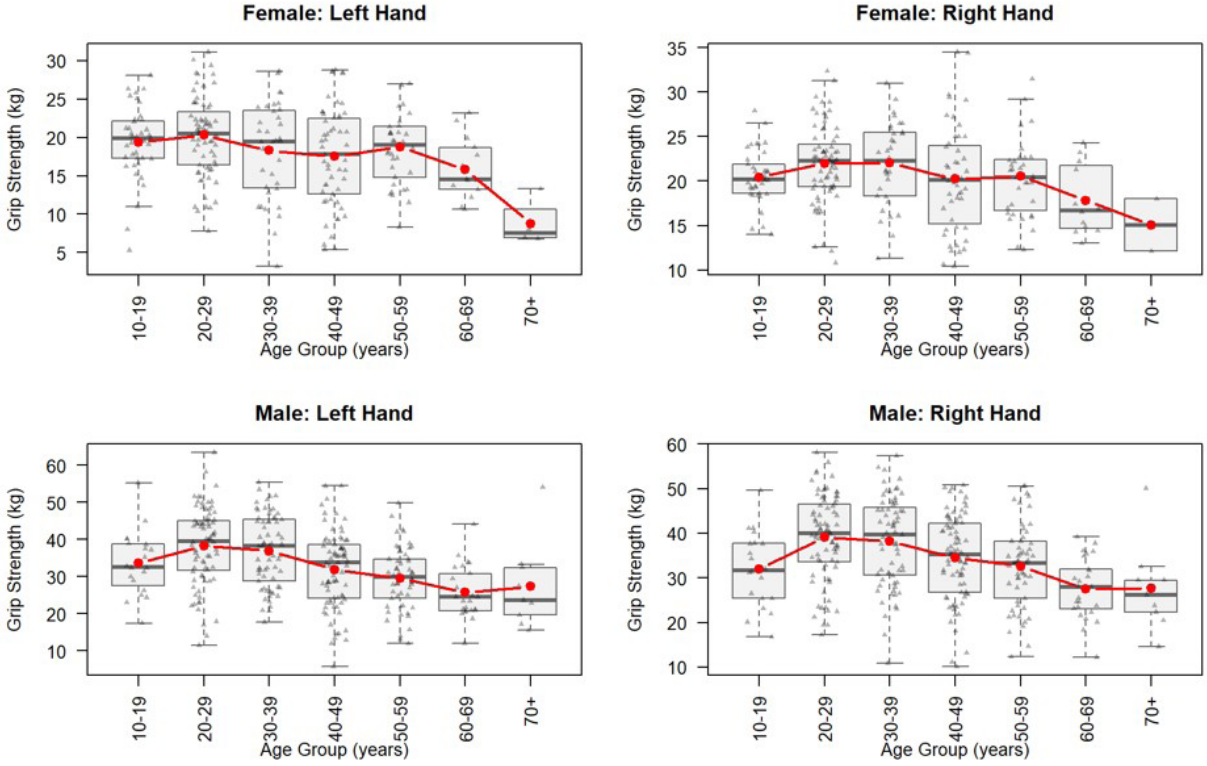

Figure 1. Peak hand grip strength by age and sex

subsequent age categories. The trend remained consistent across both hands, with the most pronounced reduction in mean grip strength occurring after age 60, reaching its lowest values in the 70+ age group.

4. Discussion

This study was conducted in the provinces of Lampung and North Sumatra, with a total of 610 respondents: 262 females and 348 males. The findings demonstrate that males have higher mean hand grip strength than females, consistent with previous findings. For instance, Kamarul and Ahmad (2006) investigated hand grip strength in the adult Malaysian population (aged 18-65 years). They found that males were consistently stronger than females across all age groups, likely due to greater muscle mass and muscle-to-fat ratios. However, their cohort primarily represented urbanized individuals with lighter physical workloads. Similarly, the large-scale GenoFit study in Ireland, which analyzed grip strength data from 9,431 adults spanning a broad age range (18-92 years), also reported significantly higher grip strength in males across

age groups (Pratt *et al*. 2023), though within a highly modernized, industrialized lifestyle context.

In contrast, studies by Putrawan and Kuswardhani (2011) and Setiawan and Setiowati (2014) in Indonesia focused solely on geriatric populations (aged 60+ years) living in institutionalized care facilities, whose physiological conditions and sedentary lifestyles differ markedly from those of the general adult population. Unlike previous reference populations, our Sumatran cohort spans a uniquely wide age range (14-87 years). It is embedded in traditional agricultural lifestyles, where intensive manual labor begins in youth and continues into old age. These contextual differences suggest that while biological sex is a key determinant of grip strength, additional factors such as occupation, physical activity level, and lifestyle also play a vital role in shaping population-specific profiles.

Regarding handedness, the linear model in this study indicates that right-hand grip strength is significantly higher overall. Out of 610 respondents, only 15 were left-handed (6 females and 9 males). While individuals who predominantly use their left hand typically show greater strength in that hand (Nurhayu *et al*. 2020), our results reflect the predominance of right-hand usage reinforced by both daily labor requirements and sociocultural norms in Sumatran society. Grip strength asymmetry was found to be more pronounced in females than in males. Bardo *et al*. (2021) found that the dominant hand was consistently stronger than the non-dominant hand in both sexes, with asymmetry influenced by factors such as occupation and type of manual activity. Their study suggested that individuals engaged in precision-based tasks — more commonly performed with the dominant hand — exhibited greater asymmetry, lending plausibility to the observed patterns in the present study.

Significant regional differences in grip strength provide further evidence of how the socio-economic environment and traditional occupational structures shape physical performance. Data indicate that participants in Central Lampung, Way Kanan, and Simalungun consistently demonstrated greater strength than those in South Lampung. Regional economic structures can explain this disparity: these areas are recognized as major agricultural hubs with extensive palm oil and sugarcane plantations. In these regions, daily physical activities involve repetitive, high-load manual movements such as gripping, lifting, and sustained muscle exertion. Physiologically, these agricultural demands promote muscle hypertrophy, enhanced hand bone mineral density, and superior neuromuscular adaptation (Bardo *et al*. 2021). In contrast, the occupational profile of South Lampung, characterized by a higher density of traders, entrepreneurs, and students, involves more sedentary or light manual tasks. This regional disparity mirrors global patterns, in which rural populations with traditional, physically demanding lifestyles exhibit higher hand-grip strength than their urban counterparts (Roland *et al*. 2016; Nurhayu *et al*. 2020; Bardo *et al*. 2021).

The positive association between income levels and hand grip strength should be interpreted through a rural sociocultural lens. In traditional Sumatran communities, higher income is often associated with better access to protein-rich nutrition and the ownership of land or livestock, which, while requiring significant physical engagement, is supported by more adequate energy intake. Interestingly, income also emerged as a significant factor, as many respondents in these rural settings hold multiple informal jobs to supplement their earnings. However, a limitation of this study is that it recorded only one primary occupation per respondent when measuring cumulative income. This may introduce some bias, as the total physical exertion from secondary manual labor tasks might not be fully captured by the primary occupational category alone.

Regarding the life-course trajectory, the analysis by age groups reveals that peak hand grip strength consistently occurs in early adulthood, specifically within the 20-29 age bracket. This aligns with the expected physiological maturity and maximum muscular output reported by Vianna *et al*. (2007). It is important to note that, although the linear regression model did not identify age as a significant predictor ($P = 0.535$), this is due to the non-linear, curvilinear relationship between age and strength. The linear model fails to capture the rise-and-fall pattern of muscle performance over time, which is better represented by the age-group analysis, which shows a clear peak in the third decade.

This peak reflects a synergy between biological maturation and the zenith of physical productivity in traditional Sumatran livelihoods. Unlike industrialized societies, these rural communities rely heavily on manual labor from a young age, imposing consistent mechanical loads that amplify neuromuscular adaptations. For males, early involvement in intensive agricultural tasks complements hormonal surges—particularly testosterone, which is positively associated with fat-free mass and grip strength (Xu *et al*. 2021; Nuzzo 2023)—to reach maximum output. Similarly, for females, this peak reflects musculoskeletal maturity coinciding with high-demand sociocultural labor patterns, including

caregiving, domestic work, and agricultural assistance. Collectively, these findings demonstrate that in traditional Sumatran communities, biological muscle performance is significantly amplified by the environmental and occupational requirements of a non-industrialized lifestyle, providing a more robust representation of physical capacity than urban-centric models.

The results underscore that in traditional populations, physical strength is not merely a product of biological maturation but a physiological adaptation to environmental and occupational demands. Furthermore, the observed dominance of right-hand strength highlights how habitual manual tasks reinforce asymmetrical muscle performance. These findings emphasize the critical need to use population-specific benchmarks—rather than urban-centric or clinical normative data—when assessing muscular health and physical capacity in non-industrialized communities.

Despite the insights gained, this study has several limitations that should be addressed in future work. Primarily, grip strength was assessed using only a single measurement per hand. While this approach was chosen for field efficiency, future research should adopt standard protocols involving 2-3 trials per hand to minimize random error and enhance measurement precision, thereby reducing potential 'noise' in age- or region-specific comparisons. Second, the occupational categorization into high- and low-manual-demand groups represents a broad dichotomy. This classification may mask significant within-occupation variation; thus, future studies should employ more granular workload indices—such as daily manual labor hours, specific task intensity, and tool handling—to better capture the nuances of occupational hand use. Furthermore, subsequent studies should include comprehensive measurements of height, weight, body mass index, smoking habits, alcohol consumption, nutritional status, and physical activity levels better to understand the multifactorial influences on hand grip strength. Incorporating these methodological refinements and additional variables will provide a more complete understanding of the determinants of muscle strength and its decline in traditional populations.

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