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Comparative Analysis of Supinated Hand Grip Strength in Standing Position among Healthy Young Adult Women in Malaysia and Thailand

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ABSTRACT

Hand grip strength (HGS) is an important indicator of upper limb function, muscle performance, and health status. However, limited research has examined grip strength in a supinated hand posture, particularly in standing position and across different Southeast Asian populations. This study aimed to compare supinated HGS between healthy young adult women in Malaysia and Thailand, and to examine the relationship between supinated HGS, age, and selected anthropometric measurements. A total of 184 right-handed female participants (92 Malaysian, 92 Thai), aged 20–39 years, were assessed. Grip strength of the dominant hand was measured in a standing posture with a fully supinated forearm using a Jamar handheld dynamometer (Sammons Preston, USA). Demographic and anthropometric data, including age, height, weight, body mass index, forearm circumference, and palm circumference, were recorded. Thai participants showed a significantly higher mean HGS (24.45 ± 5.21 kg) compared to Malaysian participants (20.38 ± 5.24 kg) ($p < 0.05$). No significant correlations or regression relationships were found between HGS, age, and anthropometric measurements in either group. This study provides the first comparative data on supinated HGS for young adult Malaysian and Thai women in standing position. The findings emphasize population-specific differences in HGS and highlight palm circumference and height as potential predictors, particularly among Thais. These results have practical implications for ergonomic design, clinical assessment, and occupational health, and contribute to the development of culturally relevant reference standards supporting the United Nations Sustainable Development Goal (SDG) 3: Good Health and Well-being.

Keywords: Hand grip strength; supination; standing; young adult women; Malaysia; Thailand

INTRODUCTION

Hand grip strength (HGS) has been widely recognized as one of the indicators for health status, with numerous studies demonstrating its association with mobility limitations (Fahrurozi et al. 2025), disease progression (Vaishya et al. 2024), cognitive impairment (Huang et al. 2022), functional disability (McGrath et al. 2021), cardiovascular events (Lopez-Jaramillo et al. 2022), and mortality (López-Bueno et al. 2022). In both ergonomics and clinical research, HGS is typically assessed in various forearm postures - neutral, pronated, and supinated, to capture orientation -specific variations in muscle engagement. Supinated HGS refers to the maximal voluntary grip force measured when the forearm is rotated palm-up, representing functional performance in tasks that require a supinated forearm and wrist orientation.

In occupational settings, many manual and service tasks naturally involve a supinated or semi-supinated wrist position. Workers in assembly, manufacturing, healthcare, and catering frequently hold or manipulate objects with the palm facing upward to improve control, precision, and stability. Similarly, technical and laboratory tasks often require sustained or repetitive supinated grips when handling instruments or materials. Evaluating HGS in supinated posture offers valuable insights for ergonomic work practices, hand tool design, and prevention of upper-limb fatigue or injury. In activities of daily living, forearm supination is essential for tasks such as carrying groceries, lifting household items, opening jars, or performing personal care activities like feeding or grooming. Assessing grip strength in a supinated position therefore reflects functional ability and independence in daily life. Assessment of hand and forearm function through advanced pose recognition and clinical evaluation techniques further highlights the importance of precise measurement protocols for activities of daily living (Hassan et al. 2025).

In sports and physical performance, the supinated HGS contributes to control, power, and precision across multiple disciplines. Exercises such as biceps curls, chin-ups, and underhand rows require strong supinated grip capacity, while racket and throwing sports like tennis, table tennis, baseball, and cricket depend on coordinated forearm supination for effective motion and force generation. Similarly, martial arts and gymnastics involve alternating supination and pronation to optimize leverage and stability. Beyond sports, in rehabilitation and clinical settings, supinated HGS serves as a useful measure for monitoring recovery after tendon or nerve injuries, assessing wrist and forearm function in conditions like arthritis or carpal tunnel syndrome, and evaluating neuromuscular performance in stroke or elderly populations. Reduced supinated grip strength can indicate muscle weakness affecting daily function or recovery progress.

Beyond its functional applications, the comparison of HGS between Malaysian and Thai populations provides meaningful scientific and practical value. Although both populations share regional proximity, differences in anthropometric characteristics, lifestyle, nutrition, and occupational patterns may influence muscular performance. Thai women were specifically selected because comparative HGS data between Malaysia and Thailand are currently scarce, despite both countries representing major Southeast Asian populations with distinct physical and lifestyle profiles. Including Thai participants therefore enables examination of population-specific variations in upper limb strength and supports the development of regionally appropriate reference standards.

Establishing comparative supinated HGS data helps clarify whether predictors such as height, weight, body mass index (BMI), and limb circumference have consistent effects across Southeast Asian populations or vary by population-specific factors. From a clinical and ergonomics perspective, such data are vital for developing population-relevant reference standards to improve health assessment, rehabilitation benchmarks, and safe work design. International reference values often fail to represent Asian body characteristics, leading to potential misinterpretation in functional or clinical evaluations. Biomechanically, HGS differs across wrist and forearm postures. Studies have shown that maximal grip strength is generally achieved in the neutral position, with slightly lower values observed in full supination due to changes in muscle length–tension relationships and wrist stabilization demands. In the supinated posture, the wrist flexors are somewhat shortened and the supinator muscles more active, which alters grip efficiency compared to the neutral position. Consequently, HGS data obtained in the neutral posture cannot be directly applied to tasks involving a supinated forearm, as doing so may overestimate actual functional capacity in that position. Measuring HGS in supination therefore offers a more ecologically valid representation of strength during activities that require a palm-up orientation of the forearm. This further highlights the need for population-specific supinated HGS data, particularly within Southeast Asian cohorts where research remains limited.

As tabulated in Table 1, numerous studies have investigated HGS in Malaysian and Thai populations; however, their methodological differences and participant characteristics limit comparability and generalization. Collectively, the literature reveals three major research gaps related to body position, forearm posture, and cross-country comparison. In Malaysia, most published works on HGS have been conducted among adults or older adults, without standardized test positions or specific consideration for cross-national comparison. For instance, Jaafar et al. 2023 assessed Malaysian participants aged 35–70 years but did not report the body position used during measurement, making methodological replication and comparison difficult. Similarly, Nor et al. 2020 examined HGS in sitting posture with varying elbow flexion angles (45°, 90°, and 135°), but their study lacked standardized standing measurements and did not include other populations. Zahudi et al. (2023) investigated tenpin bowlers in standing posture with the shoulder adjusted and elbow extended at 90°, which reflects sport-specific rather than general population conditions. Hossain Parash et al. (2022) studied young adults in Sabah, Malaysia (aged 18–25 years) using a neutral forearm posture in standing, but the absence of supinated forearm data and the focus on a regional group limited broader applicability. Other Malaysian studies further demonstrate the methodological inconsistency. Salim et al. (2021) included a wide age range (18–69 years) with unstandardized hand posture, while Kang et al. (2021) did not report body or hand positions, making inter-study comparisons problematic. Although Daruis et al. (2019) explored multiple forearm postures (neutral, supination, pronation), measurements were taken only in sitting, which does not represent functional hand use in upright postures. Likewise, Noor Hisan et al. (2017) and Hossain et al. (2012) assessed HGS in either standing or sitting with shoulder adduction or elbow flexion but did not test the standardized standing-supinated position. Most importantly, none of these Malaysian studies incorporated participants from Thailand or other countries for cross-population comparison, nor did they focus exclusively on healthy young adult women.

In Thailand, HGS research has primarily centered on male participants or older adults, with few studies involving young women. Yoopat et al. (2025) measured standing HGS among male adolescents (aged 16–20 years), while Pramkratok et al. (2024) assessed a small sample of young Thai males, both without Malaysian comparison or standardized hand posture reporting. Several Thai studies, including those by Manjavong et al. (2022), Pothisiri et al. (2021), Prasitsiriphon et al. (2019), and Horpibulsuk et al. (2019), focused exclusively on elderly or clinical populations in sitting posture, often investigating health correlates such as aging, smoking, or nutrition. Even when standardized postures were described—typically elbow flexed at 90° and wrist in neutral—these studies did not include healthy young adults. A few recent works, such as Maghfiroh et al. (2021), examined HGS among Thai youths under experimental conditions (e.g., cooling effects), yet posture details remained unreported, and no Malaysian participants were included. Earlier studies, such as Charoensri et al. (2015), developed prediction equations for HGS among adults over 20 years, but used sitting postures with shoulder adduction and ulnar deviation, diverging from standardized testing protocols.

In summary, previous Malaysian and Thai studies demonstrate three consistent shortcomings. First, none has provided a direct comparative analysis between Malaysian and Thai populations, despite the cultural and anthropometric differences that may influence HGS performance. Second, most studies focused on males, older adults, or specific athletic populations, leaving a gap in understanding the HGS characteristics among young healthy women aged 20–39 years. Third, the majority employed sitting or unreported body positions, with no study examining HGS in a standing, supinated forearm posture, which more closely represents functional activities in daily and occupational settings.

Therefore, the present study addresses these critical gaps by conducting a comparative analysis of HGS between Malaysian and Thai young adult women, measured in a standardized standing position with the forearm fully supinated. This approach provides functionally relevant, cross-national baseline data that can support ergonomic assessments, clinical evaluations, and design of hand tools and interventions tailored for Southeast Asian women. These findings contribute not only to ergonomics and clinical health assessment but also align with broader initiatives under the United Nations Sustainable Development Goal (SDG) 3, promoting health, well-being, and gender equity through evidence-based, culturally relevant research.

TABLE 1. Summary of previous studies on HGS in Malaysia and Thailand highlighting key methodological and population gaps

Studies	Populations	Age (years)	Body position	Forearm posture	Key research gaps relevant to current study
Jaafar et al. 2023	Malaysian	35–70	Not reported	Elbow flexed at 90°	Focused on older adults; body position not specified; no Thai comparison.
Nor et al. 2020	Malaysian	23–28	Sitting	45°, 90°, 135° flexions	Measured in sitting only; no standardized standing posture; no cross-country data.
Zahudi et al. 2023	Malaysian tenpin bowlers	33.81-7.82	Standing	Shoulder adduction with elbow extension (90°)	Sport-specific sample; non-standardized posture; not generalizable to young healthy women.

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Hossain Parash et al. 2022	Sabahans (Malaysian)	18–25	Standing	Elbows flexed 90°, forearms neutral	Regional sample; forearm not supinated; no Thai comparison.
Salim et al. 2021	Malaysian	18–69	Standing	Arm in neutral	Broad age range; hand posture not standardized; no cross-national data.
Kang et al. 2021	Malaysian	30–60	Not reported	Not reported	Methodological details missing; no young adult or Thai comparison.
Daruis et al. 2019	Malaysian	19–24	Sitting	Neutral, supination, and pronation	Tested multiple postures but in sitting only; not representative of standing supinated HGS.
Noor Hisan et al. 2017	Malaysian	18–30	Standing	Shoulder adduction	Standing with adducted shoulder; no neutral forearm or Thai comparison.
Yoopat et al. 2025	Thai	16–20 (male)	Standing	Hand extended downward	Male adolescents only; no Malaysian data; posture non-standardized.
Pramkratok et al. 2024	Thai	22.39-3.18 (male)	Not mentioned	Not mentioned	Small male sample; methodological details lacking; no Malaysian comparison.
Manjavong et al. 2022	Thai	≥ 60	Sitting	Full elbow flexion	Older clinical sample; not healthy young adults; no Malaysian comparison.
Pothisiri et al. 2021	Thai	≥ 60	Sitting	Elbow 90°, wrist neutral	Investigated behavioral correlates, not standardized HGS; older adults only.
Maghfiroh et al. 2021	Thai	18–21	Standing	Not mentioned	Studied effect of cooling; no standardized posture; no cross-country comparison.
Prasitsiriphon et al. 2019	Thai	60–79	Sitting	Elbow 90°, wrist neutral	Elderly population; no Malaysian data.
Horpibulsuk et al. 2019	Thai	≥ 60	Sitting	Elbow 90°, wrist neutral	Elderly focus; not comparable to young adults or Malaysian data.
Charoensri et al. 2015	Thai	> 20	Sitting	Shoulder adduction 90°, elbow 90°, ulnar deviation 30°	Developed HGS prediction model; posture not standard; no Malaysian comparison.

METHODOLOGY

PARTICIPANTS

Participants were aged 20 to 39 years, an age range selected because it represents the largest segment of the working population in both countries (Siddharta, 2025; Walderich, 2025). All participants were female and were recruited from among undergraduate and postgraduate students, as well as university staff. In Malaysia, participant recruitment was conducted across the major ethnic groups, Malay, Chinese, and Indian to represent the country's multiracial population structure. Including a multiracial sample was necessary because anthropometric characteristics and physical performance measures, including HGS, may vary across ethnic groups. This strategy improves the representativeness and applicability of the findings to Malaysian women. Additionally, participants were recruited from multiple states in both Malaysia and Thailand to ensure geographic diversity and reduce sampling bias. This regional diversity reflects variations in ethnicity, lifestyle, and nutritional practices, which may influence anthropometric characteristics and, consequently, muscle strength outcomes. Incorporating participants from multiple regions was intended to enhance the representativeness and generalizability of the findings for both Malaysian and Thai populations. Eligibility of participants was determined through an initial screening process based on predefined inclusion and exclusion criteria.

The inclusion criteria specified healthy young adults aged 20 to 39 years with a BMI between 18.5 and 24.9 kg/m². Eligible participants were required to be either Malaysian citizens or of native Malaysian origin, able to communicate in Bahasa Melayu or English, or Thai citizens who could communicate in the Thai language.

Exclusion criteria included non-Malaysian and non-Thai individuals, permanent residents, and immigrants. Pregnant women, individuals younger than 20 or older than 39 years, and those with a BMI outside the 18.5 to 24.9 kg/m² range were also excluded. Additional exclusion factors were a history of hypertension, diabetes, physical disabilities, upper-limb fractures, musculoskeletal disorders (e.g., carpal tunnel syndrome), or recent injuries affecting HGS. Furthermore, individuals who had engaged in extreme sports or physically demanding activities such as rock climbing within two weeks prior to testing were excluded to ensure accurate measurement of HGS.

The required sample size for comparing two independent groups was estimated using the following formula (Kang et al. 2021):

$$n = 2(SD^2/ \square^2) \times (Z_{1-\alpha/2} + Z_{1-\beta})^2$$

Where:

n = sample size
SD = standard deviation. A previous study reported an SD of 5.54 for female (Jaafar et al. 2023).
$Z_{1-\alpha/2}$ = 1.96, Type I error (alpha) at 5% (2-sided)
$Z_{1-\beta}$ = 0.80, Type II error at 20% (power= 80%)
Δ = detectable difference (decided to be 5, according to Kang et al. 2021)

Therefore:
$n = [2(5.54^2)/ 5^2] \text{ x } (1.96 + 0.80)^2$
n = 19 participants in each group

The calculation yielded n = 19 participants per group. In the actual measurement session, however, this study recruited a substantially larger sample, with a total of 184 participants, comprising Malaysian (n = 92) and Thai (n = 92) young adults who successfully completed the HGS measurements. This larger sample not only exceeded the minimum requirement but also enhanced the robustness and generalizability of the findings.

EXPERIMENT DESIGN AND PROCEDURE

This study adopted a cross-sectional design to assess supinated HGS among healthy young adults in Malaysia and Thailand. Supinated HGS of the dominant hand was measured using a Jamar hand-held dynamometer (Sammons Preston, USA) following the standardized protocol described by Quattrocchi et al. (2024). Measurements were recorded in kilogram-force (kg·f). Before testing, the dynamometer's functionality and accuracy were verified through calibration with standardized load masses (Daruis et al. 2019). The device was considered accurate when the displayed value matched the applied load. The indicator needle was also checked to ensure it rested at zero prior to each measurement. As illustrated in Figure 1, HGS was measured in a standardized standing posture with the wrist and forearm fully supinated (palm facing upward, with the radius and ulna in a parallel alignment) to ensure consistent positioning across all participants.

The researchers closely monitored all measurement procedures to ensure accuracy and consistency. During testing, participants stood upright in the anatomical position with their feet slightly apart, while the non-dominant arm remained relaxed at the side. To minimize shoulder abduction, the researcher verified correct positioning and, when necessary, placed a piece of paper under the armpit of the testing arm. The dynamometer handle was adjusted individually to provide a comfortable and secure grip for each participant. Participants were instructed to squeeze maximally for three seconds. Two trials were performed, and the higher value was used for statistical analysis. Hands and device handles were kept dry and clean to prevent slippage.

Before data collection, the researchers demonstrated the procedure and allowed participants to practice with the dynamometer. A minimum rest period of five minutes was provided before testing began. Participants received a full briefing about the study objectives, procedures, potential risks, and confidentiality, after which verbal consent was obtained. Upon completion, participants were thanked for their cooperation.

All testing sessions were conducted between 8:00 AM and 5:00 PM to ensure standardized conditions. Data collection took place at the Ergonomics Laboratory, Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka (UTeM), and the Biomedical Laboratory, Faculty of Engineering, Prince of Songkla University (PSU). For participants unable to attend laboratory sessions, measurements were conducted at alternative locations under safe and controlled environmental conditions.

To ensure cross-site reliability, identical measurement protocols were applied by trained researchers in both Malaysia and Thailand. Data collection was completed between January and August 2025.

FIGURE 1. The left panel shows the forearm and wrist in supinated position used for the HGS test. The center panel illustrates the standardized standing posture during measurement for a Malaysian participant, and the right panel shows the same posture for a Thai participant, demonstrating the consistent protocol used at both study sites

RESEARCH ETHICS APPROVAL

The experimental procedures were reviewed and approved by the Research Ethics Committee of Universiti Teknikal Malaysia Melaka (Reference number: UTeM.11.02/500-25/1/4 Jilid 3(4)), and the PSU Human Research Ethic Committee of Prince of Songkla University (Reference number: PSU-HREC 2024-066-1-3).

STATISTICAL ANALYSIS

Statistical analysis was conducted using JASP software (version 0.95.1). Descriptive statistics, including the minimum, maximum, mean, and standard deviation (SD), were computed to summarize the distribution and central tendency of supinated HGS values among Malaysian and Thai participants. The Shapiro–Wilk test was used to assess the normality of the data distribution, ensuring the appropriateness of subsequent parametric analyses.

An independent samples t-test was performed to compare mean supinated HGS values between Malaysian and Thai groups, determining whether significant differences existed between the two populations. The Pearson correlation test was applied to examine the relationships between supinated HGS, age, and selected anthropometric measurements such as height, weight, BMI, forearm circumference, and palm circumference, to identify potential linear associations.

Finally, a multiple linear regression analysis was conducted to examine the combined association of age and anthropometric measurements on supinated HGS and to determine which factors, if any, significantly contributed to HGS performance in a supinated forearm posture. A p-value of < 0.05 was considered statistically significant for all analyses.

RESULTS AND DISCUSSION

DESCRIPTIVE STATISTICS

Table 2 summarizes the descriptive statistics for demographic and anthropometric measurements of healthy young adult women from Malaysia (n = 92) and Thailand (n = 92). Overall, both groups were comparable in age and anthropometric measurements, although slight differences were observed in certain parameters. The mean age of the Malaysian participants was 24.54 ± 3.47 years, while the Thai participants were slightly older with a mean of 28.30 ± 5.18 years. In terms of height, Thai women were generally taller (1.651 ± 0.08 m) compared to Malaysian women (1.590 ± 0.07 m). Correspondingly, the Thai group also exhibited a higher mean body weight (58.07 ± 7.27 kg) than the Malaysian group (54.74 ± 6.52 kg). Despite these differences in height and weight, the mean BMI was comparable between the two groups—21.49 ± 1.62 kg/m² for Malaysians and 21.30 ± 1.94 kg/m² for Thais—indicating that both cohorts fell within the healthy BMI range. A notable distinction was observed in forearm and palm circumferences. Malaysian participants had a larger mean forearm circumference (23.12 ± 1.79 cm) compared to Thai participants (17.22 ± 1.50 cm), while Thai participants showed a slightly larger palm circumference (20.30 ± 1.65 cm) than Malaysians (18.47 ± 1.47 cm).

When examining supinated HGS, Thai participants demonstrated a higher mean HGS value (24.45 ± 5.21 kg) compared to Malaysian participants (20.38 ± 5.24 kg). The minimum and maximum recorded HGS values also reflected this trend, ranging from 14 to 36 kg among Thai women and 10 to 35 kg among Malaysian women. This indicates that Thai participants, on average, exhibited stronger grip performance in the supinated position, although both groups showed moderate variability as reflected by similar standard deviations (~5.2 kg). In summary, while the two cohorts were similar in anthropometric measurements and BMI classification, Thai participants tended to be taller, heavier, and stronger in terms of supinated HGS, whereas Malaysian participants exhibited larger forearm circumference.

Table 3 presents a comparative overview of dominant HGS among female participants from multiple countries, benchmarked against the present study's findings for Malaysian (20.38 kg) and Thai (24.45 kg) women, both measured in a standing, supinated forearm posture. The percentage difference was computed as [(present study – past study)/past study] × 100, while the ratio represents (present study ÷ past study). Positive values indicate higher HGS in the current study, whereas negative values indicate lower strength compared to prior data.

Overall, the present results fall within the lower-to-mid range of internationally reported HGS values, most of which were obtained using a neutral forearm posture. Among Malaysian participants, the mean supinated HGS of 20.38 kg was comparable to that reported by Daruis et al. (2019) (18.0 kg), showing a +13.2% difference. Notably, Daruis et al. (2019) also assessed HGS in a supinated posture, but measurements were taken in a sitting position, whereas the current study was performed in standing. This finding aligns with previous evidence from Uysal et al. (2022) and Xu et al. (2021), who both reported that HGS measured in standing posture tends to be higher than that obtained while sitting. The enhancement in standing position can be attributed to greater activation of stabilizing muscles in the trunk and lower limbs, which improves postural control and facilitates more efficient force transmission from the body to the hand during gripping (Jain et al. 2018; Kong, 2014). Furthermore, the supinated HGS observed in this study was 8.9% lower than the values reported by Jaafar et al. and 15.8% higher than those reported by Hossain et al. both of whom assessed HGS in the neutral forearm posture among Malaysian participants.

These differences reflect the combined effects of testing methodology (e.g. body position and forearm posture), anthropometric measurements, and sampling characteristics. The Malaysian mean also aligned closely with regional data from Indonesia (–5.2%) and India (+4.5%). Notably, Saravanan et al. who also measured HGS in a supinated posture among Indian women, reported a mean of approximately 21 kg—remarkably close to the current Malaysian value. This agreement reinforces the consistency of supinated HGS measurements among South and Southeast Asian populations.

Among Thai participants, the mean HGS (24.45 kg) exceeded or closely matched most previous findings from Thailand and neighboring countries, including Charoensri et al. (15.0–25.0 kg) and Maghfiroh et al. (25.3 kg). Ratios ranging from 0.97 to 1.63 indicate that the Thai women in this study demonstrated comparatively stronger HGS, potentially due to greater upper-limb conditioning or the biomechanical advantage conferred by the supinated, standing position, which can enhance flexor muscle activation. The Thai mean also paralleled East Asian data from China (24.4–25.5 kg) and Korea (25.3–27.2 kg), placing this group within the upper-Asian strength range.

When compared cross-nationally, the Malaysian and Thai means were lower than those of Western populations, such as Australia (29–31 kg), Germany (30.5–32.3 kg), the USA (28.1–29.6 kg), Great Britain (28.4–31.4 kg), and Italy (28.9 kg). Ratios between 0.63 and 0.87 highlight population-level strength disparities, consistent with anthropometric differences such as smaller average body and hand sizes, and lower muscle mass. Similarly, mean values for both groups were somewhat below those reported for Iran (27.8 kg), where women demonstrated 12–27% higher HGS, possibly reflecting variations in body composition and participants selection.

It is also noteworthy that most prior datasets were derived using a neutral forearm posture, whereas the present study adopted a supinated posture. Supination modifies wrist alignment and forearm muscle recruitment—particularly engaging the biceps brachii and supinator synergists—which may lead to different force outputs. Thus, direct comparison should be interpreted with caution. Nevertheless, the current findings indicate that supinated HGS values remain largely comparable to those from neutral postures, supporting their functional validity and relevance to real-world tasks that involve palm-up or object-supporting positions.

In summary, the Malaysian and Thai women in this study exhibited moderate supinated HGS values consistent with regional patterns but distinctly lower than Western norms. These findings highlight population-specific differences influenced by multiple factors such as posture, physical size, and occupational activity.

TABLE 2. Descriptive statistics of demography/ anthropometry of female Malaysian and Thailand participants

Demography/ Anthropometry	Malaysia (n = 92)				Thailand (n = 92)			
	Min	Mean	Max	SD	Min	Mean	Max	SD
Age (year)	20.20	24.54	39.00	3.47	20.10	28.30	39.00	5.18
Height (m)	1.46	1.590	1.80	0.07	1.47	1.651	1.820	0.08
Weight (kg)	40.00	54.74	68.00	6.52	45.30	58.07	76.55	7.27
BMI (kg/m^2)	18.67	21.49	24.61	1.62	18.51	21.30	24.86	1.94
Forearm circumference (cm)	19.00	23.12	29.00	1.79	14.00	17.22	22.00	1.50
Palm circumference (cm)	16.00	18.47	26.00	1.47	15.00	20.30	24.00	1.65
Supinated HGS (kg)	10.00	20.38	35.00	5.24	14.00	24.45	36.00	5.21

TABLE 3. Mean supinated HGS (kg) of the dominant hand among female participants in previous studies across different countries, compared with values from the present study (Malaysia and Thailand)

Previous study/ Country	Forearm posture	HGS (kg)	Present study (Malaysian), mean HGS = 20.38 kg		Present study (Thai), mean HGS = 24.45 kg	
			Percentage difference	Ratio	Percentage difference	Ratio
Daruis et al./ Malaysia	Supinated	18.00	13.2%	1.13	35.8%	1.36
Saravanan et al./ India	Supinated	23.90	-14.7%	0.85	2.3%	1.02
Jaafar et al. / Malaysia	Neutral	22.38	-8.9%	0.91	9.2%	1.09
Hossain et al. / Malaysia	Neutral	17.60	15.8%	1.16	38.9%	1.39
Charoensri et al. / Thailand	Neutral	15.00	-18.5%	0.82	-2.2%	0.98
Charoensri et al. / Thailand	Neutral	25.00	35.9%	1.36	63.0%	1.63
Maghfiroh et al. (2021)/ Thailand	Neutral	25.3	-19.4%	0.81	-3.4%	0.97
Nawangsasi et al. / Indonesia	Neutral	21.49	-5.2%	0.95	13.8%	1.14
Mullerpatan et al. / India	Neutral	19.51	4.5%	1.04	25.3%	1.25
Bimali et al. / Nepal	Neutral	27.56	-26.1%	0.74	-11.3%	0.89
Bimali et al. / Nepal	Neutral	33.11	-38.4%	0.62	-26.2%	0.74
Lee et al. / Korea	Neutral	25.30	-19.4%	0.81	-3.4%	0.97
Lee et al. / Korea	Neutral	27.20	-25.1%	0.75	-10.1%	0.90
He et al. / China	Neutral	24.44	-16.6%	0.83	0.0%	1.00
He et al. / China	Neutral	25.55	-20.2%	0.80	-4.3%	0.96
Yu et al. / China	Neutral	21.80	-6.5%	0.93	12.2%	1.12
Yu et al. / China	Neutral	22.00	-7.4%	0.93	11.1%	1.11
Ekşioğlu et al. / Turkey	Neutral	25.80	-21.0%	0.79	-5.2%	0.95
Ekşioğlu et al. / Turkey	Neutral	30.50	-33.2%	0.67	-19.8%	0.80
Massy-Westropp et al. / Australia	Neutral	29.00	-29.7%	0.70	-15.7%	0.84
Massy-Westropp et al. / Australia	Neutral	31.00	-34.3%	0.66	-21.1%	0.79

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Huemer et al. / Germany	Neutral	30.50	-33.2%	0.67	-19.8%	0.80
Huemer et al. / Germany	Neutral	32.30	-36.9%	0.63	-24.3%	0.76
Ramirez-Velez et al. / Columbia	Neutral	24.80	-17.8%	0.82	-1.4%	0.99
Ramirez-Velez et al. / Columbia	Neutral	25.30	-19.4%	0.81	-3.4%	0.97
Wang et al. / USA	Neutral	28.10	-27.5%	0.73	-13.0%	0.87
Wang et al. / USA	Neutral	29.60	-31.1%	0.69	-17.4%	0.83
Dodds et al./ Great Britain	Neutral	28.40	-28.2%	0.72	-13.9%	0.86
Dodds et al. / Great Britain	Neutral	31.40	-35.1%	0.65	-22.1%	0.78
Zaccagni et al./ Italy	Neutral	28.90	-29.48%	0.71	-15.40%	0.84
Rostamzadeh et al./ Iran	Neutral	27.80	-26.69	0.73	-12.05%	0.88

NORMALITY TEST

Table 4 presents the results of the normality test for supinated HGS data among Malaysian and Thai female participants. Normality was evaluated using descriptive (skewness and kurtosis) and inferential (Shapiro–Wilk) indicators to determine whether the data satisfied the assumptions required for parametric statistical analyses. For the Malaysian group, the skewness value was 0.395 and kurtosis was –0.327, while for the Thai group, skewness was 0.127 and kurtosis was –0.539. These values are within the commonly accepted range of ±1, indicating that both datasets approximate a normal distribution. The Shapiro–Wilk statistic further supported this observation, with W = 0.973 (p = 0.054) for Malaysian participants and W = 0.983 (p = 0.266) for Thai participants.

Because both p-values exceeded the 0.05 significance threshold, the null hypothesis of normality was not rejected for either group. This suggests that the supinated HGS data for both Malaysian and Thai female participants are normally distributed, satisfying the assumption of normality required for subsequent parametric test, the independent t-test.

In summary, the results indicate that the distribution of supinated HGS values in both populations was approximately normal, with no significant skewness or kurtosis. This validates the use of parametric statistical methods for comparing supinated HGS between the two groups.

TABLE 4. Normality test of supinated HGS data of female Malaysian and Thai

	HGS data of Malaysian	HGS data of Thai
Skewness	0.395	0.127
Kurtosis	-0.327	-0.539
Shapiro-Wilk	0.973	0.983
P-value of Shapiro-Wilk	0.054	0.266

COMPARATIVE ANALYSIS

An independent samples t-test was conducted to compare the supinated HGS between Malaysian and Thai female participants. As shown in Table 5, the analysis revealed a statistically significant difference in mean supinated HGS between the two groups.

The mean supinated HGS of Thai participants was 24.45 ± 5.22 kg, which was notably higher than that of Malaysian participants (20.38 ± 5.24 kg). The difference of approximately 4.1 kg suggests a substantial disparity in supinated HGS performance between the two populations. The Student's t-test yielded a t-value of –5.274 with 182 degrees of freedom and a p-value < 0.001, indicating that this difference was highly significant at the 0.05 level.

To verify the robustness of this result, a non-parametric Mann–Whitney U test was also performed, producing a U statistic of 2471.000 and a p-value < 0.001, which further confirmed the significant difference in HGS between the two groups. The mean rank for the Thai group (111.64) was higher than that of the Malaysian group (73.36), indicating consistently greater supinated HGS scores among Thai participants across the distribution.

The coefficient of variation (CV) showed moderate variability in both groups, 0.257 for Malaysians and 0.213 for Thais. These findings suggest that supinated HGS performance was relatively stable within each sample. The standard error of the mean (SE) was nearly identical between groups (0.546 for Malaysians and 0.544 for Thais), demonstrating comparable sampling precision. Overall, the findings indicate that Thai women exhibited significantly higher supinated HGS than Malaysian women of similar age range (20–39 years).

Figure 2 illustrates the mean supinated HGS values for Malaysian and Thai female participants measured in a standardized standing posture. Both the descriptive error plot (left) and the bar chart (right) clearly illustrate the higher mean HGS observed among Thai participants compared to their Malaysian counterparts, with minimal overlap in standard deviation bars, visually reinforcing the statistically significant group difference ($p < 0.001$). The Thai participants exhibited a higher mean HGS (24.45 ± 5.21 kg) compared to the Malaysian participants (20.38 ± 5.24 kg). The error bars, representing one standard deviation, show minimal overlap, visually supporting the statistically significant difference confirmed by the independent samples t-test ($p < 0.001$).

This difference suggests that Thai women in the 20–39 year age group possess greater hand grip strength than their Malaysian counterparts, despite similar demographic and anthropometric ranges. Factors potentially influencing this disparity may include physical activity, occupational demands, lifestyle differences, or variations in muscle conditioning across populations.

Overall, the graphical representation reinforces the quantitative findings that nationality significantly influences hand grip performance when measured under standardized conditions of posture and grip orientation.

TABLE 5. Results of independent samples t-test

	Test	Statistic	df	p-value
HGS (kg)	Student	-5.274	182	< 0.001
	Mann-Whitney	2471.000		< 0.001

Group	n	Mean	SD	SE	Coeff. of variation	Mean rank	Sum rank
Malaysian	92	20.38	5.241	0.546	0.257	73.36	6749
Thai	92	24.45	5.215	0.544	0.213	111.64	10271

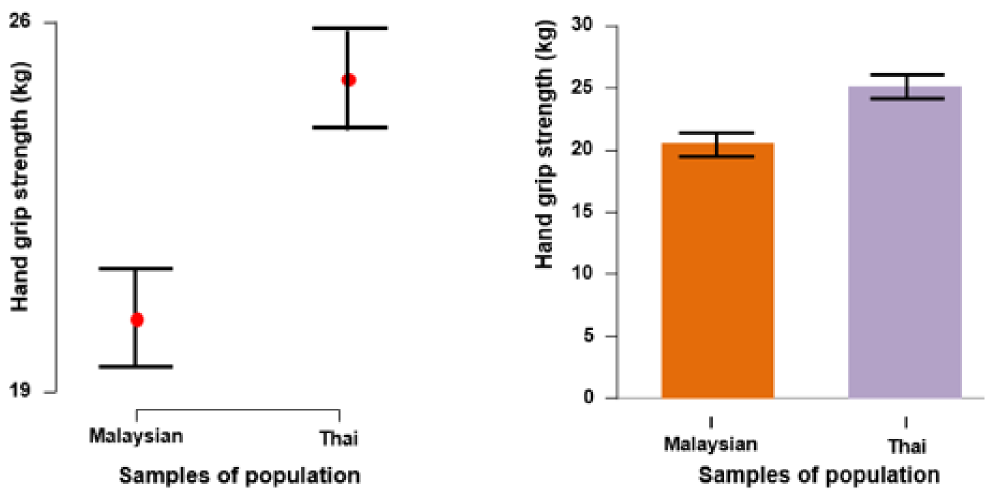

FIGURE 2. Mean supinated HGS of Malaysian and Thai female participants shown using a descriptive error plot (left) and a bar chart (right). Both visualizations indicate higher mean HGS among Thai participants compared to Malaysians, with error bars (±1 SD) showing limited overlap, reflecting the statistically significant between-group difference

CORRELATION ANALYSIS BETWEEN SUPINATED HGS, AGE, AND ANTHROPOMETRY

Table 6 presents the Pearson's correlation analysis examining the relationship between supinated HGS and selected anthropometric parameters among Malaysian female participants. The results show no statistically significant correlations between HGS and any of the tested variables, including age ($r = 0.104$, $p = 0.323$), height ($r = –0.005$, $p = 0.960$), weight ($r = 0.030$, $p = 0.775$), body mass index (BMI) ($r = 0.048$, $p = 0.647$), forearm circumference ($r = 0.008$, $p = 0.940$), and palm circumference ($r = 0.052$, $p = 0.621$). These findings suggest that, within the studied Malaysian female cohort aged 20–39 years, HGS in a supinated position is not significantly influenced by those basic anthropometric measures. The weak and non-significant correlations indicate a relatively homogenous sample, where variations in body size or limb dimensions do not substantially affect supinated HGS performance. This may imply that other factors, such as neuromuscular efficiency, regular hand exercises, or physical activity level, could play a more dominant role in determining supinated HGS in this population.

Among Thai female participants, the Pearson's correlation analysis (Table 7) revealed no significant associations between supinated HGS and the measured anthropometric variables. Specifically, the supinated HGS showed weak, non-significant correlations with age (r = –0.088, p = 0.407), height (r = 0.098, p = 0.355), weight (r = 0.109, p = 0.299), body mass index (BMI) (r = 0.048, p = 0.649), forearm circumference (r = 0.125, p = 0.233), and palm circumference (r = 0.088, p = 0.403).

These results indicate that variations in body size or limb dimensions among Thai young adult women did not significantly influence the HGS when measured in a supinated posture. The absence of strong correlations suggests that HGS performance in this group may depend more on functional and neuromuscular factors rather than basic anthropometric characteristics. This pattern is consistent with the Malaysian findings, emphasizing that anthropometry alone is not a reliable predictor of supinated HGS in either population under standardized testing conditions.

TABLE 6. Pearson's correlation analysis among Malaysian participants

			Pearson's *r*	p-value
Supinated HGS (kg)	-	Age	0.104	0.323
Supinated HGS (kg)	-	Height	-0.005	0.960
Supinated HGS (kg)	-	Weight	0.030	0.775
Supinated HGS (kg)	-	BMI	0.048	0.647
Supinated HGS (kg)	-	Forearm circumference	0.008	0.940
Supinated HGS (kg)	-	Palm circumference	0.052	0.621

TABLE 7. Pearson's correlation analysis among Thai participants

			Pearson's *r*	p-value
Supinated HGS (kg)	-	Age	-0.088	0.407
Supinated HGS (kg)	-	Height	0.098	0.355
Supinated HGS (kg)	-	Weight	0.109	0.299
Supinated HGS (kg)	-	BMI	0.048	0.649
Supinated HGS (kg)	-	Forearm circumference	0.125	0.233
Supinated HGS (kg)	-	Palm circumference	0.088	0.403

In the present study, the relationships between age, height, weight, BMI, forearm circumference, and palm circumference with supinated HGS were weak or non-significant in both Malaysian and Thai participants. This finding suggests that these anthropometric variables may not be strong predictors of HGS performance when the wrist is positioned in supination. The observation aligns partially with some previous studies but contrasts with others, indicating that the association between anthropometric measurements and HGS remains inconclusive across populations, measurement postures, and age groups.

Several studies have reported weak or non-significant correlations between BMI and HGS, consistent with the current findings. For instance, Sui et al. (2020) found that HGS was not associated with BMI in Australian women, while Abd El Mawgod et al. (2024) reported very weak positive and negative correlations between BMI and HGS in male and female students, respectively. Similarly, Kemala Sari et al. (2024) observed no significant differences in HGS across BMI classifications among Indonesian adults. A study among Indian medical students also revealed no significant correlation between BMI and HGS (Chattopadhyay et al. 2024), whereas Soraya and Parwanto (2023) emphasized that findings on this relationship remain controversial and inconsistent across age and sex.

In contrast, other researchers have observed positive but modest relationships between BMI or other anthropometric measurements and HGS. For example, Lopes et al. (2018) and Lad et al. (2013) noted low positive correlations between BMI and HGS, although the significance varied between genders. Agtuahene et al. (2023) also identified moderate positive associations between HGS and both BMI and height, while weight showed no notable effect. More recently, Wei et al. (2025) proposed that the Body Roundness Index (BRI) might outperform BMI as a predictor of HGS, suggesting that more complex geometric indicators could better reflect muscle mass distribution.

Regarding forearm and palm dimensions, the present results contrast with studies that found significant positive correlations between these anthropometric measurements and HGS. For instance, Alahmari et al. (2017) and Joseph Oliver Raj et al. (2019) reported that forearm circumference was directly related to HGS in young and middle-aged men, while Rostamzadeh et al. (2020) and Mahmoud et al. (2020) found similar associations in general adult and child populations, respectively. Furthermore, Byambaa et al. (2023) identified forearm circumference as one of the key determinants of HGS in a population-based Mongolian cohort. Conversely, Camacho-Villa et al. (2024) observed only weak-to-moderate correlations between upper limb dimensions and dominant HGS in female volleyball players.

As for height and weight, results across studies are also mixed. Some investigations, such as those by Lopes et al. (2018), Zaccagni et al. (2020), and Rostamzadeh et al. (2020), demonstrated positive associations of HGS with height and weight, while others (e.g., Kemala Sari et al. 2024; the present study) reported no meaningful relationship. Overall, these mixed results highlight that the predictive strength of anthropometric measurements for HGS is population- and context-dependent. The current findings show weak or no associations in supinated posture, suggesting that biomechanical or neuromuscular factors such as muscle mass, physical fitness, or hand exercises may exert greater influence on supinated HGS than anthropometric measurements alone.

Beyond anthropometry, several additional factors may help explain the observed population differences in supinated HGS between Malaysian and Thai women. First, genetic variability may play a role, as inherited differences in muscle fibre composition, tendon insertion angles, and neuromuscular activation efficiency can influence HGS independently of body size. Second, habitual physical activity patterns differ between Malaysian and Thai women; for example, Thai women may engage in higher levels of moderate-intensity daily activities such as walking, manual tasks, or traditional exercises that could enhance upper limb muscle conditioning. Third, cultural and occupational factors may also contribute; for example, certain work roles or domestic tasks more common in Thailand may involve frequent lifting, carrying, or manual handling in a supinated posture. Additionally, nutritional differences may further influence muscle function. Diets higher in protein quality or micronutrients related to muscle metabolism (e.g., iron, vitamin D) have been linked to stronger grip performance, and national dietary patterns differ between Malaysia and Thailand.

MULTIPLE LINEAR REGRESSION

A multiple linear regression was conducted to examine whether age, height, weight, BMI, forearm circumference, and palm circumference predicted supinated HGS among Malaysian female participants. The overall model was not statistically significant, $F(6,85) = 0.24$, p-value = 0.962, with $R^2 = 0.017$ and adjusted $R^2 = -0.053$, indicating that the predictors collectively explained only 1.7% of the variance in the supinated HGS. None of the individual predictors reached statistical significance ($p > 0.05$). These results suggest that the included anthropometric variables did not meaningfully predict supinated HGS within this Malaysian female group. The resulting regression model was expressed as follows (using unstandardized coefficients):

Supinated HGS (kg) = 112.104 + 0.119(Age) − 62.745(Height) + 0.888(Weight) − 2.157(BMI) − 0.032(Forearm Circumference) + 0.208(Palm Circumference)

As shown in Table 8, none of the predictor variables demonstrated statistically significant relationships with HGS ($p > 0.05$ for all variables). Age ($\beta = 0.079$, $p = 0.515$), height ($\beta = –0.816$, $p = 0.580$), weight ($\beta = 1.106$, $p = 0.594$), BMI ($\beta = –0.667$, $p = 0.608$), forearm circumference ($\beta = –0.011$, $p = 0.937$), and palm circumference ($\beta = 0.059$, $p = 0.651$) all exhibited weak associations with the dependent variable.

Similarly, a multiple linear regression analysis was performed to examine whether age, height, weight, BMI, forearm circumference, and palm circumference could predict supinated HGS among Thai female participants. Likewise, the Thai model was not significant, $F(6,85) = 0.52$, $p = 0.794$, with $R^2 = 0.035$ and adjusted $R^2 = -0.033$, and no single predictor showed a meaningful association with grip strength ($p > 0.05$).The regression equation derived from the unstandardized coefficients is presented as follows:

Supinated HGS (kg) = −15.371 − 0.142(Age) + 21.502(Height) − 0.208(Weight) + 0.667(BMI) + 0.180(Forearm Circumference) + 0.155(Palm Circumference)

As summarized in Table 9, none of the anthropometric variables significantly predicted HGS (all $p > 0.05$). Age ($\beta = –0.141$, $p = 0.247$), height ($\beta = 0.329$, $p = 0.800$), weight ($\beta = –0.290$, $p = 0.863$), BMI ($\beta = 0.243$, $p = 0.836$), forearm circumference ($\beta = 0.051$, $p = 0.743$), and palm circumference ($\beta = 0.049$, $p = 0.725$) exhibited weak and non-significant relationships with HGS.

TABLE 8. Coefficients of multiple linear regression for Malaysian participants

Model	df (reg., res.)	F	p-value	R^2	Adjusted R^2	Unstandardized	Std. Error	Standardized (β)	p-value
M_0 (Intercept)						20.380	0.546		< .001
M_0 (Intercept)	6, 85	0.24	0.962	0.017	−0.053	112.104	178.860		0.532
Age						0.119	178.860	0.079	0.515
Height						-62.745	0.182	-0.816	0.580
Weight						0.888	112.893	1.106	0.594
BMI						-2.157	1.659	-0.667	0.608
Forearm circum.						-0.032	4.193	-0.011	0.937
Palm circum.						0.208	0.399	0.059	0.651

TABLE 9. Coefficients of multiple linear regression for Thai participants

Model	df (reg., res.)	F	p-value	R^2	Adjusted R^2	Unstandardized	Std. Error	Standardized (β)	p-value
M_0 (Intercept)						24.446	0.544		< .001
M_0 (Intercept)	6, 85	0.52	0.794	0.035	−0.033	-15.371	139.677		0.913
Age						-0.142	0.122	-0.141	0.247
Height						21.502	84.690	0.329	0.800
Weight						-0.208	1.199	-0.290	0.863
BMI						0.667	3.222	0.243	0.836
Forearm circum.						0.180	0.547	0.051	0.743
Palm circum.						0.155	0.438	0.049	0.725

In the present study, multiple linear regression analyses were conducted separately for Malaysian and Thai female participants to determine whether age, height, weight, BMI, forearm circumference, and palm circumference could predict supinated HGS. For both populations, the regression models were not statistically significant (Malaysia: $F(6,85) = 0.24$, $p = 0.962$, $R^2 = 0.017$; Thailand: $F(6,85) = 0.52$, $p = 0.794$, $R^2 = 0.035$), and none of the individual predictors reached significance (all $p > 0.05$). These findings indicate that, in a supinated and standing posture, the selected anthropometric parameters did not meaningfully explain variations in HGS among young adult women.

This outcome contrasts with several earlier studies that identified significant associations between anthropometric or demographic factors and HGS. For instance, Hossain et al. (2011) reported that in an adult Malaysian population, HGS was negatively associated with age ($p < 0.01$) and positively correlated with height and BMI (both $p < 0.001$), suggesting that taller and heavier individuals generally exhibited stronger hand grip. Similarly, Moy et al. (2011) found that weight, height, race, and age were statistically significant predictors of HGS among elderly Malaysian females, implying that body size and demographic characteristics contribute to strength variability. Furthermore, Lopes et al. (2018) demonstrated that forearm circumference and hand length were significant predictors of HGS in young to middle-aged adults, with their model explaining 71% of the variance in grip performance. Likewise, Moy et al. (2015) and Shaheen et al. (2021) found that age, BMI, and limb circumferences were reliable predictors of grip strength in different adult cohorts.

The lack of significant associations in the current study may be attributed to several methodological and physiological differences compared with prior research. First, forearm posture plays a critical role in muscular activation during gripping tasks. Previous studies typically measured HGS in a neutral forearm posture, which maximizes mechanical leverage for the flexor muscles and may therefore enhance the apparent influence of anthropometric factors. In contrast, the supinated posture used in this study alters muscle recruitment patterns, involving more selective activation of the biceps brachii and supinator muscles, thereby reducing the predictive value of general body dimensions.

Second, participant characteristics differ markedly. Earlier studies included mixed-gender or elderly groups with wider variation in muscle mass, and body proportions, which tend to produce stronger correlations with HGS performance. In contrast, the present participants comprised healthy, young adult women within a relatively narrow range of age and body size, leading to restricted variance and consequently weaker statistical relationships.

Overall, the present findings indicate that anthropometric dimensions alone do not adequately predict supinated HGS among healthy young women in Malaysia and Thailand. This suggests that HGS in a supinated posture is likely influenced by additional physiological and behavioral factors beyond simple body measurements, including muscle mass, neuromuscular efficiency, hand-use patterns, and physical activity. Consistent with the review by Halim et al. (2019), HGS is recognized as a multifactorial attribute shaped by individual characteristics (e.g., age, ethnicity, gender, handedness), occupational demands (e.g., job type, working hours), environmental conditions (e.g., time of day, temperature), and hand unilateral training.

The observed population-level difference in supinated HGS between Malaysian and Thai young adult women is consistent with emerging evidence that cross-country variation in grip performance reflects differences in occupational activity, habitual exercise, and muscle conditioning, as well as methodological factors such as testing posture. Recent Malaysian studies (e.g., Jaafar et al. 2023) have shown that occupation, body size, and activity level significantly influence HGS, while Thai data indicate higher values among individuals with regular upper-body or physically demanding tasks. Beyond these physiological and occupational influences, the choice of testing supination posture (palm-up) versus neutral (thumb-up) has practical and interpretive implications. The neutral posture is generally preferred in population-based assessments for its ergonomics comfort, ease of standardization, and functional resemblance to everyday gripping, thereby enhancing measurement reliability (Núñez-Cortés et al. 2022; Fan et al. 2018). However, the supination posture, while less practical for large-scale testing, may elicit higher maximal readings due to greater activation of the forearm flexors and biceps, and it may be more representative of specific occupational or sport-related demands, such as in manufacturing, laboratory work, or racquet sports that involve repeated supinated grip motions. Consequently, postural selection in HGS testing can interact with occupational conditioning, potentially amplifying or masking true inter-population differences. Therefore, when interpreting disparities in HGS between Malaysian and Thai young women, it is essential to consider not only differences in work patterns and muscle conditioning but also the practicality and task relevance of the measurement posture used.

CONCLUSION

This study examined the comparative HGS performance in a supinated position among healthy young adult women from Malaysia and Thailand, using standardized standing posture and controlled measurement protocols. A total of 184 participants (92 Malaysians and 92 Thais) aged 20 to 39 years were assessed, with anthropometric parameters including height, weight, BMI, forearm circumference, and palm circumference recorded.

The results revealed a significant difference in supinated HGS between the two populations, with Thai participants demonstrating higher mean grip strength (24.45 ± 5.21 kg) than Malaysian participants (20.38 ± 5.24 kg) ($p < 0.001$). Normality tests confirmed the suitability of parametric analyses, while correlation and regression results showed no significant associations between supinated HGS and any anthropometric measurements in either group. This suggests that, within this age range, HGS performance in a supinated posture is not strongly influenced by body size or limb dimensions.

Overall, the findings highlight a population-based difference in supinated HGS, potentially reflecting variations in occupational activity, lifestyle, or muscle conditioning between Malaysian and Thai young adult women. Importantly, this study provides the first comparative data for supinated HGS measured in a standing posture, a functionally relevant but previously underexplored position. These results offer valuable reference values for ergonomics, occupational assessment, and clinical applications, and contribute to the development of population-specific standards supporting safe and efficient task design involving a supinated forearm posture.

In addition, the findings offer practical guidance for industries in which workers frequently handle objects in a supinated or near-supinated posture (e.g., assembly work, packaging, inspection, and materials handling). Understanding typical HGS capability in this posture can inform job matching, work–rest schedules, and tool or handle design to reduce fatigue and improve productivity.

From a clinical perspective, supinated HGS data may support assessment of functional upper-limb performance in rehabilitation settings, especially for conditions affecting wrist and forearm musculature. Clinicians may use these posture-specific reference values to monitor recovery progress, identify strength deficits, and tailor exercise prescriptions more accurately according to task demands.

Future work should explore HGS performance across broader age groups, male participants, and other forearm postures to establish comprehensive normative databases for Southeast Asian populations. Longitudinal or intervention-based studies examining the influence of physical activity, occupational types, and training on grip performance would also help clarify the underlying factors contributing to inter-population differences observed in this study.

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DECLARATION OF COMPETING INTEREST

None.

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