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Reference Values for Maximal Isometric Handgrip and Pinch Strength in Healthy Italian Adults Without Occupational Biomechanical Overload

Emma Sala[1,2,*], Nicola Riolfi[2], Alessandro De Bellis[2], Andrea Bisioli[2], Cesare Tomasi[2], Francesco Romagnoli[2], Giuseppe De Palma[1,2]

[1]Unit of Occupational Health, Hygiene, Toxicology and Prevention, ASST Spedali Civili di Brescia, Brescia, Italy
[2]Unit of Occupational Health and Industrial Hygiene, Department of Medical and Surgical Specialties, Radiological Sciences and Public Health, University of Brescia, Brescia, Italy

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Abstract

Background*: Handgrip strength (HGS) and pinch strength are key indicators of hand function with relevant clinical and ergonomic implications. In Italy, normative reference values for combined grip and pinch strength measurements in healthy adults not exposed to upper-limb biomechanical overload are currently lacking. The primary aim of this cross-sectional study was to provide descriptive reference values for HGS and three pinch types, stratified by sex and age group, in a healthy Italian adult population (18–65 years) not exposed to occupational biomechanical overload. The secondary aim was to investigate the influence of sex, age, body mass index (BMI), and hand dominance, as well as the relationships among strength measures.* **Methods***: A total of 813 participants (319 men and 494 women) were evaluated. Measurements were performed using a calibrated Baseline® hand dynamometer and pinch gauge according to the standardized protocol of the American Society of Hand Therapists (ASHT).* **Results***: Men showed higher strength values than women across all measures. The association between body mass index (BMI) and strength was more pronounced and consistent in women than in men, with statistical significance observed only for selected pinch measures in men. Strength values showed a non-linear distribution across age groups, with peak levels observed between 30 and 49 years in men and between 40 and 49 years in women. Hand dominance showed a selective effect in both sexes, influencing specific pinch tasks but not handgrip strength.* **Conclusions***: This study provides the first national joint normative dataset for handgrip and pinch strength in healthy Italian adults aged 18–65 years not exposed to occupational biomechanical overload. These findings may support clinical and occupational assessments and contribute to the development of broader Italian normative reference tables.*

1. Introduction

Handgrip strength (HGS) represents the maximal voluntary force generated by the combined contraction of extrinsic and intrinsic muscles acting across the joints of the hand [1, 2]. It is a practical, safe, non-invasive, reliable, and feasible method for assessing muscle strength across all age groups. The test can be easily administered by minimally trained personnel and is readily interpretable in clinical

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*Corresponding Author: Emma Sala; E-mail: emma.sala@unibs.it

settings [3, 4]. Accordingly, it is routinely used by occupational physicians, occupational therapists, and other trained professionals in a wide range of clinical contexts. Evidence indicates that grip strength is an appropriate proxy for overall muscular strength [5], reflects the impact of neuromuscular and musculoskeletal disorders as well as cardiovascular diseases, and represents an important indicator in the diagnosis of sarcopenia [6] and frailty [7], as well as a predictor of mortality [8]. Pinch strength refers to the force generated by thumb opposition against the distal phalanges of other fingers and can be evaluated using standardized tasks, including pulp pinch, lateral (key) pinch, and tip pinch [9].

A widely accepted approach for interpreting HGS test results is to compare them with normative reference values. Such norms allow individual performance to be evaluated relative to peers of the same sex and age, facilitating the identification of individuals with reduced muscle strength who may be at increased health risk or require intervention, as well as those with higher strength levels who may exhibit superior physical or occupational performance. Normative values can also be used to monitor physiological ageing by assessing longitudinal changes in strength capacity [10]. In occupational medicine, they are additionally useful for evaluating outcomes of surgical or rehabilitative interventions, monitoring recovery after injury or illness, and supporting fitness-for-work assessments. In occupational health practice, grip and pinch strength measurements are also frequently used to support functional evaluations and return-to-work assessments. Therefore, reliable normative data for grip and pinch strength are essential for multiple clinical and occupational applications.

Normative values for HGS and pinch strength have been widely reported for decades; however, most available datasets derive from local or regional samples rather than nationally representative populations, and frequently cover restricted age ranges rather than the entire adult lifespan [11–29]. Numerous factors are known to influence HGS, including age, height, body weight, and body mass index (BMI). Several studies have shown that HGS is consistently higher in men than in women across comparable age groups throughout adulthood (20–69 years). Peak HGS has been reported between 25 and 50 years [36], whereas a recent systematic review suggests a peak between 30 and 39 years [10]. Variability in HGS has been shown to correlate negatively with age and positively with wrist, arm, and hand circumference, palm length, and arm muscle mass. Other potential determinants include BMI and height, although findings regarding these variables remain inconsistent [20, 27]. Differences between dominant and non-dominant hands have also been described, with the dominant hand generally reported to be approximately 10% stronger [36].

Normative reference values should ideally be derived from representative samples collected within the last 15–20 years [13]. Comparisons across populations indicate regional variability [16, 24], particularly between developed and developing countries [31, 32]. Consequently, despite the recent publication of international normative values by Tomkinson et al. in 2024 [10] based on a very large dataset (approximately 2.4 million individuals), such variability may limit the direct applicability of international norms to specific national populations [12]. To the best of our knowledge, in the Italian context, although recent studies have proposed normative values for grip strength [33] and pinch strength [34], a comprehensive dataset providing combined reference values for both grip and pinch strength in healthy adults aged 18–65 years not exposed to upper-limb biomechanical overload is still lacking.

The present study was designed to address this gap. The primary objective was to estimate reference values for HGS and three pinch types (lateral, three-point, and tip-to-tip) stratified by sex and age group in a sample of healthy adults aged 18–65 years not occupationally exposed to biomechanical overload of the upper limbs and without a history of substantial non-occupational upper-limb overload. Secondary objectives were to investigate the influence of sex, age, BMI, and hand dominance on strength measures, to assess relationships between grip and pinch strength, and to compare the findings with normative data available from other countries.

2. Methods

2.1. Study Design and Population

A cross-sectional study was conducted in a sample of 813 healthy adults (319 men and 494 women) aged 18–65 years who were not occupationally exposed to upper-limb biomechanical overload. Participants were recruited during routine occupational health surveillance examinations performed by occupational physicians at two large hospital organizations in Northern Italy (Brescia and Trento) between November 2020 and June 2025. Written informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All data were anonymized prior to analysis and processed in accordance with the EU General Data Protection Regulation (GDPR 2016/679) and national privacy regulations.

Exclusion criteria included any current or previous musculoskeletal, neurological, or metabolic condition potentially affecting upper-limb strength. Individuals self-reporting secondary occupations or leisure activities (e.g., sports or manual hobbies) involving relevant biomechanical loading of the upper limbs were also excluded.

For analytical purposes, participants were stratified into five age groups: 18–29 years (Group 1), 30–39 years (Group 2), 40–49 years (Group 3), 50–59 years (Group 4), and 60–65 years (Group 5).

2.2. Anthropometric and Descriptive Variables

For each participant, the following anthropometric and descriptive variables were recorded: sex, age, height, body weight, and body mass index (BMI), calculated as weight in kilograms divided by height in meters squared (kg/m^2). Hand dominance was assessed by self-report and classified into four categories: right-handed, left-handed, ambidextrous, and corrected left-handed. These variables were collected to enable stratified analyses by sex and age group and to examine potential associations between anthropometric characteristics and grip and pinch strength outcomes.

2.3. Strength Assessment Protocol

Handgrip strength (HGS) and pinch strength were measured using a Baseline® hydraulic hand dynamometer and a Baseline® mechanical pinch gauge, respectively. All assessments were performed in accordance with the standardized protocol of the American Society of Hand Therapists (ASHT). Participants were evaluated in a seated position with the shoulder adducted and neutrally rotated, the elbow flexed at 90°, the forearm in neutral position, and the wrist positioned between 0–15° of extension and 0–15° of ulnar deviation. For handgrip testing, the dynamometer handle was set at the second position for all participants.

Both instruments were calibrated by the manufacturer and periodically recalibrated throughout the study in accordance with technical specifications to ensure measurement accuracy. All measurements were performed by two trained assessors to minimize inter-rater variability. When necessary, a third trained operator assisted with data recording and participant management.

Pinch strength was assessed bilaterally using three pinch types in the following order:

1. Lateral pinch (key pinch) (Figure 1).
2. Three-point pinch (Figure 2).
3. Tip-to-tip pinch (Figure 3).

For pinch strength assessment, two trials per hand were performed in alternating sequence. Handgrip strength was subsequently evaluated with three trials per hand. For each strength variable, the final recorded value was calculated as the arithmetic mean of valid trials.

A trial was considered valid when the variability between repeated measurements did not exceed 10%. If this criterion was not satisfied, an additional trial was performed. A standardized rest interval of approximately 15 seconds was allowed between consecutive trials to minimize fatigue effects. Standardized verbal instructions were provided without motivational encouragement. Participants were instructed to progressively increase force to a maximal voluntary contraction over approximately 1 second

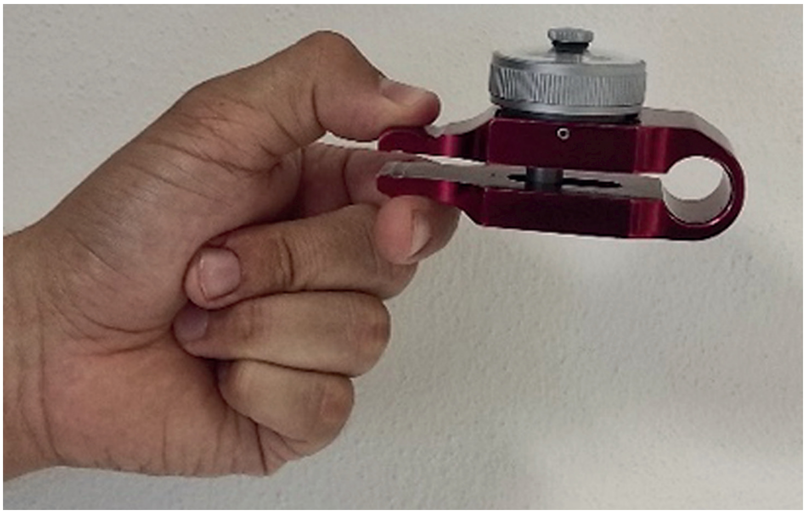

Figure 1. SEQ Figura * ARABIC 1: Lateral pinch (Key pinch).

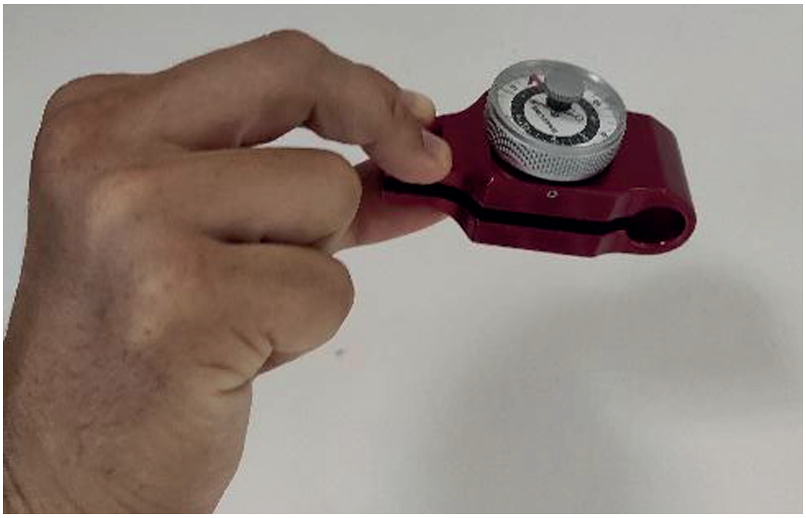

Figure 2. Three point pinch (TTT).

and to maintain the contraction for approximately 4 seconds.

Figure 4 shows the standardized testing position for handgrip strength assessment according to the ASHT protocol. Participants were seated with the shoulder adducted and neutrally rotated, the elbow flexed at 90°, the forearm in neutral position, and the wrist positioned between 0–15° of extension and 0–15° of ulnar deviation. The figure illustrates hand positioning for handgrip strength and for the three pinch types (lateral pinch, three-point pinch, and tip-to-tip pinch).

2.4. Statistical Analysis

Data were initially entered into Microsoft Excel® and subsequently analyzed using IBM SPSS® Statistics (version 26.0.1; IBM Corp., Armonk, NY, USA).

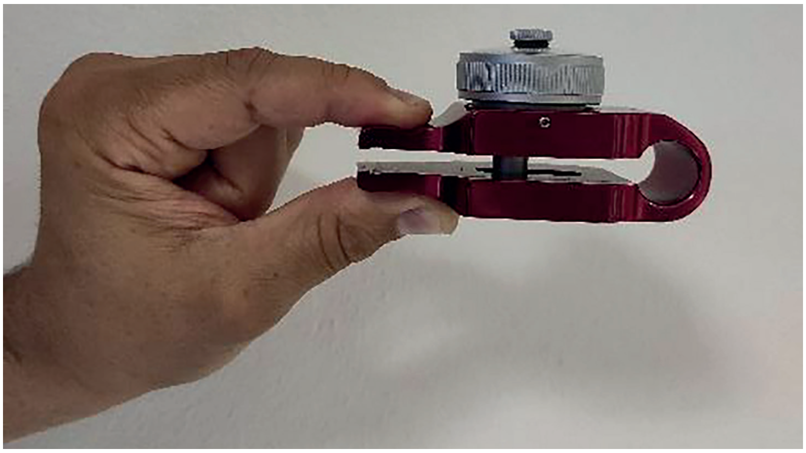

Figure 3. Two point pinch (tip to tip).

Figure 4. Hand Grip Strenght Test.

The distribution of continuous variables was assessed using the Kolmogorov–Smirnov test with Lilliefors correction. Because grip and pinch strength variables were not normally distributed, nonparametric statistical methods were used. Descriptive statistics are presented as medians and ranges (minimum–maximum). Differences between sexes were evaluated using the Mann–Whitney U test. Comparisons across age groups (18–29, 30–39, 40–49, 50–59, and 60–65 years) and hand dominance categories were performed using the Kruskal–Wallis test.

Associations between categorical variables (e.g., sex and hand dominance) were examined using Pearson's chi-square test. To investigate relationships between anthropometric continuous variables and strength outcomes, Spearman's rank correlation coefficients were calculated between age, BMI, and each grip and pinch strength measure. Correlation analyses were stratified by sex to explore potential sex-specific patterns in the association between BMI and strength. Age-related trends were assessed both through correlation analyses and through comparisons across predefined age groups, allowing identification of potential non-linear (non-monotonic) patterns across the adult lifespan rather than assuming a single linear decline. All statistical tests were two-tailed, and p-values were calculated.

3. RESULTS

3.1. Study Population

A total of 813 participants were included in the analysis, comprising 319 men (39.2%) and 494 women (60.8%). The demographic and anthropometric characteristics of the study population are summarized in Table 1.

3.2. Normative Handgrip and Pinch Strength Values

Sex- and age-specific normative values for handgrip strength and pinch strength (lateral pinch, three-point pinch, and tip-to-tip pinch), measured bilaterally, are reported in Table 2.

Across all age groups, men consistently showed higher median values than women for all grip and pinch strength measures. In both sexes, strength values followed a non-linear age-related pattern, with higher values observed in early and mid-adulthood and a progressive decline in older age groups. Overall, the distribution of strength values across age groups suggested peak levels in early to mid-adulthood.

3.3. Grip and Pinch Strength Differences By Sex

Comparisons between men and women showed significantly higher grip and pinch strength in men across all measures. These differences were confirmed by the Mann–Whitney U test for all grip and pinch variables. No significant difference in age distribution between sexes was observed (P = 0.462).

3.4. Hand Dominance Distribution

The distribution of hand dominance by sex is reported in Supplementary Table S1. A statistically significant association between sex and hand dominance was observed (χ^2 = 8.313; df = 3; P = 0.040). Analysis of adjusted residuals indicated that this association was driven exclusively by the category of corrected left-handedness, which was overrepresented among men and underrepresented among women. No significant deviations from expected frequencies were observed for right-handed, non-corrected left-handed, or ambidextrous participants.

3.5. Correlations Between Anthropometric Variables and Strength Measures

Spearman correlation analyses stratified by sex are reported in Supplementary Tables S2 (men) and S3 (women). In men, age showed weak correlations with strength measures, including a weak negative correlation with right-hand grip strength and weak positive correlations with selected pinch measures. Body mass index showed weak but statistically significant positive correlations with selected pinch measures, whereas correlations with grip strength

Table 1. Demographic and Anthropometric Characteristics of the Study Population.

Sex	Participants (n)	% of Total	Age, years, median (range)	BMI, kg/m^2 (median [range])
Men	319	39.2	40 (18–65)	24.38 (16.5–38.8)
Women	494	60.8	43 (18–65)	22.04 (15.9–47.8)
Total	813	100	42 (18–65)	23.14 (15.9–47.8)

Table 2a. Normative Handgrip and Pinch Strength Values in Men by Age Group (Median and Range, kg).

Age Group (years)	n Men	Grip R (Men)	Grip L (Men)	Lat. Pinch R (Men)	Lat. Pinch L (Men)	TPP R (Men)	TPP L (Men)	Tip-to-Tip R (Men)	Tip-to-Tip L (Men)
18–29	93	51.00 (29.00–71.00)	48.33 (23.33–71.00)	10.50 (6.50–16.75)	10.00 (6.25–15.50)	9.00 (5.50–13.25)	8.50 (5.50–14.75)	6.75 (3.75–11.50)	6.50 (3.75–10.50)
30–39	66	53.00 (14.25–92.66)	49.66 (14.50–80.66)	11.25 (7.00–17.00)	10.44 (7.25–16.00)	9.25 (5.75–15.00)	9.00 (5.50–14.50)	7.25 (4.50–10.25)	7.00 (4.00–9.50)
40–49	54	52.50 (35.33–73.00)	49.66 (33.33–75.00)	11.00 (5.50–15.50)	10.19 (7.00–14.25)	9.50 (5.25–13.00)	9.00 (5.00–13.75)	7.25 (4.75–11.00)	7.44 (3.75–11.50)
50–59	73	48.33 (35.00–72.33)	46.00 (32.00–64.00)	10.75 (6.50–15.10)	10.25 (6.25–15.25)	9.25 (6.00–14.87)	8.75 (6.00–14.12)	7.00 (4.13–12.00)	7.00 (4.50–11.75)
60–65	33	48.66 (25.00–65.00)	46.00 (21.33–61.66)	10.50 (7.50–12.50)	10.25 (7.38–12.75)	9.00 (6.50–12.00)	8.50 (5.25–12.00)	7.00 (4.88–10.25)	6.50 (5.38–9.38)
Total	319	50.66 (14.25–92.66)	48.00 (14.50–80.66)	10.75 (5.50–17.00)	10.25 (6.25–16.00)	9.00 (5.25–15.00)	8.75 (5.00–14.75)	7.00 (3.75–12.00)	7.00 (3.75–11.75)

Table 2b. Normative Handgrip and Pinch Strength Values in Women by Age Group (Median and Range, kg).

Age Group (years)	n Women	Grip R (Women)	Grip L (Women)	Lat. Pinch R (Women)	Lat. Pinch L (Women)	TPP R (Women)	TPP L (Women)	Tip-to-Tip R (Women)	Tip-to-Tip L (Women)
18–29	115	31.33 (20.00–54.33)	28.33 (15.66–51.00)	7.50 (4.75–10.50)	7.00 (4.00–15.75)	6.00 (3.25–11.25)	5.75 (2.50–10.00)	5.00 (2.80–7.75)	4.50 (2.80–7.00)
30–39	104	32.00 (22.00–45.00)	29.00 (16.33–43.00)	7.75 (4.00–10.50)	7.25 (3.50–12.00)	6.75 (4.00–11.00)	6.38 (4.00–10.00)	5.00 (3.25–7.00)	4.75 (3.00–7.50)
40–49	114	33.33 (18.66–56.66)	30.83 (15.66–51.66)	7.75 (3.50–11.00)	7.50 (3.00–11.00)	7.00 (2.75–11.75)	6.50 (2.75–12.00)	5.25 (2.50–10.38)	5.00 (2.50–9.00)
50–59	124	30.66 (13.33–43.33)	28.50 (12.00–40.99)	7.50 (3.75–10.50)	7.00 (3.25–11.50)	6.63 (2.75–12.00)	6.25 (2.50–13.75)	5.13 (2.25–7.75)	5.00 (2.50–8.00)
60–65	37	27.66 (18.66–43.33)	25.00 (18.00–40.66)	7.00 (4.75–9.75)	6.25 (4.50–10.00)	6.00 (4.50–8.50)	6.00 (4.25–9.00)	4.75 (3.50–7.25)	4.25 (3.00–7.00)
Total	494	31.00 (13.33–56.66)	28.67 (12.00–51.66)	7.50 (3.50–11.00)	7.00 (3.00–15.75)	6.50 (2.75–12.00)	6.00 (2.50–13.75)	5.00 (2.25–10.38)	4.75 (2.50–9.00)

were weaker and not consistently significant. All grip and pinch strength measures were positively intercorrelated.

In women, age was weakly negatively correlated with right-hand grip strength and weakly positively correlated with selected pinch measures. Body mass index showed weak but statistically significant positive correlations with all grip and pinch strength measures. As observed in men, all strength measures were positively intercorrelated.

3.6. Effect of Hand Dominance On Strength Measures

Differences in grip and pinch strength across hand dominance categories were evaluated separately in men and women using the Kruskal–Wallis test (Supplementary Table S4).

In men, statistically significant differences across dominance categories were observed only for left-hand lateral pinch and right-hand tip-to-tip pinch, whereas no significant differences were detected for handgrip strength or the remaining pinch measures. In women, statistically significant differences across dominance categories were observed only for right-hand three-point pinch, with no significant differences for handgrip strength or other pinch measures.

3.7. Differences in Strength Measures Across Age Groups

Differences in grip and pinch strength across age groups were assessed separately for men and women using the Kruskal–Wallis test (Supplementary Table S5).

In men, statistically significant differences across age groups were observed for body mass index, bilateral handgrip strength, left-hand three-point pinch, and bilateral tip-to-tip pinch, whereas no significant differences were found for lateral pinch strength or right-hand three-point pinch. In women, statistically significant differences across age groups were observed for all tested variables, including body mass index, bilateral handgrip strength, and all pinch strength measures.

4. Discussion

In this study, men exhibited higher handgrip and pinch strength values than women across all measured variables. This finding is consistent with large population-based cohorts and recent international syntheses reporting higher peak strength and greater values across the adult lifespan in men compared with women [10, 13, 23, 28, 29]. These differences are plausibly related to well-established biological factors, including differences in muscle mass, hormonal profiles, and body composition, and further support the use of sex-specific normative reference values.

The association between body mass index (BMI) and strength differed by sex. In women, BMI showed weak but consistent positive correlations with all grip and pinch strength measures, whereas in men significant associations were limited to selected pinch tasks (Supplementary Tables S2 and S3). This pattern suggests a more consistent association between BMI and manual strength in women, potentially related to sex-specific differences in body composition and fat–lean mass distribution. Overall, these findings are consistent with previous studies reporting positive associations between BMI and strength [12, 14, 17], while also aligning with evidence indicating non-linear or heterogeneous relationships between BMI and hand strength [18, 27]. Further investigations in larger and more diverse samples are warranted to clarify these sex-specific associations.

The combined analysis of sex- and age-stratified normative values (Table 2), age-group comparisons, and correlation analyses indicates that strength trajectories across adulthood are non-linear. For most measures, strength peaked in young to mid-adulthood, followed by a gradual decline in older age groups. In some pinch measures, particularly in men, strength profiles appeared relatively stable across age groups, suggesting lower sensitivity to age-related gradients. This observation is consistent with findings first reported by Mathiowetz et al. in 1985. [15].

Overall, the age-related pattern observed in this study follows a non-linear (bell-shaped) trajectory corresponding to the expected profile described in international reference curves, with a peak in early adulthood and a progressive decline thereafter [10, 13, 29]. A slight shift in peak strength was observed between sexes, with peak values occurring at 30–49 years in men and 40–49 years in women. This minor discrepancy compared with large transnational datasets reporting a peak at 30–39 years [10] may reflect sample-specific characteristics. The weak Spearman correlation coefficients observed are likely explained by the non-monotonic and age-dependent nature of the age–strength relationship.

In the present sample, the effect of hand dominance on strength measures was selective rather than generalized. In men, significant differences between dominance categories were observed only for left-hand lateral pinch and right-hand tip-to-tip pinch, whereas in women a significant effect was detected only for right-hand three-point pinch (Supplementary Table S4). No consistent dominance-related differences were observed for handgrip strength (HGS).

These findings partially contrast with reports describing a general dominance-related advantage for both handgrip and pinch strength [13, 14, 18, 34, 36], but are consistent with studies reporting no systematic differences between dominant and non-dominant hands [37]. Methodological differences, particularly the use of between-group dominance analyses rather than within-subject comparisons, may have attenuated small individual asymmetries and contributed to the observed discrepancies.

Finally, all grip and pinch strength measures were positively and strongly intercorrelated, indicating a coherent functional profile of manual strength. Positive correlations were also observed between contralateral measures (e.g., right vs. left handgrip), supporting the internal consistency and reliability of the measurement protocol (Supplementary Tables S2 and S3).

Beyond the occupational medicine framework, the availability of national normative reference values for handgrip and pinch strength has relevant implications across several medical disciplines. Handgrip strength is widely recognised as a sensitive and early marker of neuromuscular function and is routinely applied in neurology and neurorehabilitation for monitoring both peripheral and central nervous system disorders, including multiple sclerosis, amyotrophic lateral sclerosis, peripheral neuropathies, and post-stroke functional outcomes.

In rheumatology and hand orthopaedics, grip and pinch strength represent core functional outcomes in conditions directly affecting hand performance, such as rheumatoid arthritis, hand osteoarthritis, Raynaud's phenomenon, and connective tissue diseases, as well as in the evaluation of recovery following surgical procedures including distal radius fracture fixation, tendon reconstruction, carpal tunnel release, and wrist arthroplasty.

In geriatrics and ageing medicine, handgrip strength is a recognised diagnostic criterion for sarcopenia according to the EWGSOP2 consensus and a robust predictor of mortality, disability, hospitalisation, and cognitive decline. Although the present study includes individuals up to 65 years of age, the proposed reference values may represent a useful baseline for future longitudinal studies investigating muscle strength trajectories in older Italian populations.

Further applications extend to internal medicine and oncology, where grip strength is increasingly used as a proxy for muscle mass and nutritional status in patients with chronic diseases and cancer, and is incorporated into frailty indices and preoperative risk stratification tools. In these settings, comparison with national reference values may improve the accuracy of functional assessment and risk classification. Additional fields of application include endocrinology and diabetology, sports medicine and motor sciences, paediatrics, and psychosomatic medicine, where grip and pinch strength are increasingly employed as integrative functional and health-related indicators.

From a methodological perspective, the availability of sex- and age-stratified normative values derived from an Italian population reduces the bias associated with the use of North American or Northern European reference data, which have been shown to systematically overestimate strength in Mediterranean populations. This aspect represents one of the most robust and clinically transferable contributions of the present study and supports the use of these reference values across both occupational and non-occupational clinical contexts.

5. Study limitations and future perspectives

Several limitations should be acknowledged. First, specific upper-limb anthropometric measures (e.g., limb circumferences, hand dimensions, and forearm muscle mass), which are known to influence grip and pinch strength [14, 16, 21], were not collected. Inclusion of these variables in future studies may help explain part of the observed variability and allow a more precise normalization of strength values.

Second, maximal voluntary contraction is inherently effort-dependent and may be influenced by participant motivation and operator-related factors. Although standardized ASHT procedures, calibrated instruments, and trained assessors were used, a residual degree of measurement variability cannot be excluded. Future studies may benefit from standardized pre-test familiarization procedures, uniform verbal instructions, and additional practice trials.

Third, the study population was limited to two geographical areas and to adults aged 18–65 years not occupationally exposed to upper-limb biomechanical overload. Consequently, the results cannot be generalized to younger individuals, adults over 65 years of age, or workers exposed to occupational upper-limb biomechanical risk factors. Expanding both the sample size and the age range represents an important objective for future research.

In addition, recruitment during occupational health surveillance may introduce a potential healthy worker effect.

Finally, this study did not include formal statistical comparisons with large international datasets. Such analyses will be addressed in future work to explore transnational and regional differences and to contribute to the development of broader normative reference tables.

Despite these limitations, the present sample represents one of the largest Italian cohorts currently available for the normative assessment of hand strength and provides the first combined national reference dataset for both grip and pinch strength in healthy Italian adults.

6. Conclusions

This study provides the first Italian national joint normative reference values for handgrip strength and three pinch strength measures in healthy adults aged 18–65 years. Measurements were conducted according to the standardized ASHT protocol using calibrated instruments and trained assessors in a large sample comprising 319 men and 494 women not occupationally exposed to upper-limb biomechanical overload.

These reference values are directly applicable in both clinical practice and occupational medicine, including the evaluation of surgical and rehabilitative outcomes, monitoring of injury- and disease-related functional impairment, assessment of fitness for work, and prognostic evaluation in frail individuals. More broadly, normative strength data support health, safety, comfort, productivity, and the ergonomic design of tools and tasks. In occupational settings, handgrip strength assessment is particularly relevant for pre-employment screening, workload estimation, and return-to-work evaluations.

Although international and some Italian reference data on handgrip or pinch strength are available, this study uniquely provides joint normative values for both grip and pinch strength in a healthy Italian population. The resulting dataset represents a valuable quantitative contribution to future Italian and international reviews and meta-analyses and provides a robust foundation for the development of more comprehensive national normative reference tables.

Institutional Review Board Statement: All evaluations performed in the study were included in occupational risk assessment and health surveillance activities that are mandatory by law under the Italian D.Lgs. 81/08 (Testo Unico sulla Salute e Sicurezza sul Lavoro). Consistent with the criteria established by the Italian Ministry of Health Decree of 30 January 2023 for observational studies conducted in the context of occupational health monitoring, formal approval by an Ethics Committee was not required. All participants provided written informed consent prior to enrollment. The study was conducted in accordance with the WMA Declaration of Helsinki and the General Data Protection Regulation (GDPR, Regulation EU 679/2016).

Declaration of Interests: The authors declare no conflict of interest.

Author Contributions: E. Sala conceived and designed the study and drafted the manuscript; F. Romagnoli conceived the study; N. Riolfi, A. De Bellis, and A. Bisioli collected the data; C. Tomasi performed the statistical analysis; G. De Palma conceived the study and critically revised the manuscript. All authors critically revised the manuscript and approved the final version.

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APPENDIX

Supplementary Table S1. Hand Dominance by Sex (Chi-Square Analysis).

Test	Value	df	p value
Pearson χ^2	8.31	3	0.040
Likelihood ratio	8.557	3	0.036

Note: The association was driven by corrected left-handedness.

Supplementary Table S2. Spearman Correlation Matrix – Men.

	Age	BMI	Grip R	Grip L	Lateral Pinch R	Lateral Pinch L	TPP R	TPP L	Tip-to-tip R
BMI	0.28**								
Grip R	-0.12*	0.08							
Grip L	-0.11	0.04	0.89**						
Lateral Pinch R	-0.04	0.12*	0.45**	0.40**					
Lateral Pinch L	-0.03	0.10	0.44**	0.47**	0.82**				
TPP R	0.06	0.09	0.42**	0.39**	0.62**	0.59**			
TPP L	0.11*	0.10	0.40**	0.41**	0.58**	0.67**	0.85**		
Tip-to-tip R	0.12*	0.21**	0.47**	0.47**	0.52**	0.47**	0.63**	0.60**	
Tip-to-tip L	0.18**	0.22**	0.42**	0.46**	0.41**	0.50**	0.51**	0.60**	0.82**

**. Correlation is significant at the 0.01 level (two-tailed).
*. Correlation is significant at the 0.05 level (two-tailed).
*Spearman's rho. *$p < 0.05$; *$p < 0.01$.
R = right hand.
L = left hand.

Supplementary Table S3. Spearman Correlation Matrix – Women.

	Age	BMI	Grip R	Grip L	Lateral Pinch R	Lateral Pinch L	TPP R	TPP L	Tip-to-tip R
BMI	0.28**								
Grip R	-0.11*	0.13**							
Grip L	-0.06	0.13**	0.89**						
Lateral Pinch R	-0.04	0.16**	0.46**	0.40**					
Lateral Pinch L	-0.03	0.21**	0.47**	0.47**	0.82**				
TPP R	0.08	0.14**	0.40**	0.31**	0.57**	0.55**			
TPP L	0.09*	0.19**	0.40**	0.37**	0.51**	0.60**	0.88**		
Tip-to-tip R	0.04	0.22**	0.49**	0.45**	0.54**	0.56**	0.63**	0.60**	
Tip-to-tip L	0.06	0.22**	0.54**	0.55**	0.55**	0.63**	0.55**	0.61**	0.81**

**. Correlation is significant at the 0.01 level (two-tailed).
*. Correlation is significant at the 0.05 level (two-tailed).

Supplementary Table S4. Effect of Hand Dominance on Strength Measures (Kruskal–Wallis Test).

Sex	Significant variables ($p < 0.05$)
Men	Lateral Pinch Left; Tip-to-Tip Right
Women	Three-Point Pinch Right

Supplementary Table S5. Differences in Strength Measures Across Age Groups (Kruskal–Wallis Test).

Sex	Variables with significant differences
Men	BMI; Grip R; Grip L; TPP L; Tip-to-Tip R/L
Women	All tested variables