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Systematic Review

Association Between Anaemia and Handgrip Strength: A Systematic Review and Meta-Analysis

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Abstract

Introduction: Anaemia impairs oxygen delivery to tissues, potentially compromising muscle function. Handgrip strength (HGS) is validated marker of muscle function, frailty, and health outcomes. **Objective:** To synthesize evidence on the association between anaemia and HGS in adults across diverse settings. **Methods:** MEDLINE, JSTOR, and Google Scholar were searched up to May 2025 using MeSH terms and keywords related to anaemia and handgrip strength. Of 510 identified records, 12 studies met the inclusion criteria. Two reviewers independently screened studies, extracted data, and assessed risk of bias using Joanna Briggs Institute checklists. Random-effects meta-analysis was performed in RevMan(v4.3.0) to pool odds ratios for weak handgrip strength among anaemic versus non-anaemic individuals. **Results:** Across studies, anaemia was consistently associated with poor HGS. Meta-analysis included three studies that provided comparable effect estimates and sufficient quantitative data for pooling; the remaining studies were synthesized narratively indicated that individuals with anaemia had 59% greater odds of weak grip strength (OR=1.59, 95%CI,1.07–2.37), with considerable heterogeneity. Subgroup analysis revealed stronger associations in men (OR=2.13, 95%CI,1.35–3.34) than in women (OR=1.30, 95%CI,1.05–1.78), and the effects were more pronounced in older adults (particularly in >65 years). **Conclusion:** Anaemia is associated with reduced handgrip strength, particularly among men and older adults in our findings. These findings suggest that handgrip strength may reflect functional impairment related to anaemia and could be useful as simple functional assessment measure in resource-limited settings. Further longitudinal studies are needed to clarify causality and the impact of anaemia treatment on muscle strength and functional outcomes.

Key Words: Anaemia, Hand Strength, Mass Screening

Introduction

Handgrip strength (HGS) is an objective and reproducible marker of muscular function and overall physical health. It is widely used as a surrogate indicator of sarcopenia and frailty and has prognostic value for cardiometabolic disease, disability, and mortality.[1] Another study conducted by Lee Wei et al.[2] reported that relative HGS could be used to assess cardiovascular health in public health. Similarly, a study conducted in Canadian children aged 6–19 years revealed that in girls, HGS is associated with cardiometabolic health.[3] Another study reported that there is an inverse relationship between HGS and mortality risk.[4] Another study reported that HGS is useful in the prediction of overall health outcomes.[5] Given the growing evidence linking muscle strength with overall health status, examining the association between anaemia and HGS may provide important insights into functional health and nutritional status.

Anaemia is defined as a reduced red blood cell count or haemoglobin concentration in the body below 13 g/dl in men and 12 g/dl in women, leading to impaired oxygen delivery to tissues. According to the World Health Organization, anaemia affects approximately 40% of children aged 6–59 months, 37% of pregnant women, and 30% of women aged 15–49 years globally, contributing significantly to functional impairment, fatigue, reduced physical capacity, and poor health outcomes.[6] Anaemia is linked to both short- and long-term morbidity, with women, children under five, and adolescents being particularly vulnerable.[7] Its pathophysiological effects stem from reduced oxygen-carrying capacity, leading to tissue hypoxia and diminished muscular performance.

The biological plausibility of a link between anaemia and reduced muscle strength is well established by various individual studies.[8,9] Anaemia reduces oxygen delivery to muscle tissue, thereby impairing mitochondrial oxidative metabolism, limiting ATP generation, and resulting in muscle fatigue and weakness.[10] In Yu-mi Gi et al[11], 2020 study, anaemia was negatively associated with both absolute and relative HGS indices, with stronger associations observed in men than in women.

That study used data from the Korean National Health and Nutrition Examination Survey, which revealed that individuals with weak HGS had a higher odds ratio for anaemia, particularly males and those aged 65 and older. In the Indonesian elderly population, a positive correlation was found between haemoglobin levels and HGS, with anaemia significantly associated with weak HGS. This association was more pronounced in males and those aged 80 years and above.[12] Other studies have investigated haemoglobin thresholds, iron status markers, and their relationships with HGS, but the results remain heterogeneous and context specific.

Despite this growing body of evidence, the literature remains fragmented, with heterogeneity in study design, population characteristics, definitions of anaemia, and methods of HGS measurement. There is currently no systematic review that comprehensively synthesizes these findings across diverse settings. Such a synthesis is essential to clarify the strength and consistency of the association and to inform whether HGS could be integrated into anaemia-related screening and risk stratification, particularly in older adults and populations in resource-limited settings where advanced diagnostics are not readily available.

Therefore, this systematic review aimed to critically evaluate and summarize the available evidence on the association between anaemia and handgrip strength in adult populations across different geographic and clinical contexts.

Methods

Protocol and Registration:

The protocol was prospectively registered on PROSPERO (CRD420251047729). The review was conducted as per the methodology described in the Cochrane Handbook for Systematic Reviews of Interventions and is reported as per the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines.[13]

Search strategy:

We conducted a comprehensive search of MEDLINE (via PubMed), JSTOR, and Google Scholar for studies published up to May 2025, using a structured combination of MeSH terms and free-text keywords. The search focused on terms related to anaemia (e.g., “Anaemia,” “Hemoglobin,” “Anemia”) and handgrip strength (e.g., “Grip Strength,” “Handgrip Strength,” “Dynamometer,” “Muscle Strength”). A PubMed search string included ‘("Anemia"[Mesh] OR anemia[tiab] OR hemoglobin[tiab]) AND ("Hand Strength"[Mesh] OR "Muscle Strength"[Mesh] OR "Grip Strength"[tiab] OR "Handgrip Strength"[tiab] OR "Hand Grip"[tiab] OR "Muscle Strength"[tiab] OR dynamometer[tiab] OR "hand-held dynamometer"[tiab])’. We also reviewed gray literature sources and the reference lists of key articles to identify additional studies. Only English-language published literature was included.

Eligibility criteria:

We included observational studies (cross-sectional, cohort, case–control), interventional studies (RCTs or quasi experimental), or baseline data from trials reporting on the association between anaemia and handgrip strength in human populations of any age, sex, or setting (community-based or clinical). Anaemia had to be defined by objective haemoglobin measures (WHO or study-specific thresholds), and handgrip strength was measured quantitatively with validated dynamometry. Studies reporting comparative or association data between anaemia and HGS were needed. We excluded case reports, small case series (<10 participants), editorials, commentaries, letters, reviews, protocols, animal or in vitro studies, and any reports without quantitative data on anaemia or handgrip strength.

Study Selection:

Two independent reviewers screened the titles and abstracts retrieved from the search. Full-text articles were assessed for eligibility on the basis of the inclusion and exclusion criteria. Any disagreements between reviewers were resolved by discussion, and if needed, a third reviewer was consulted. The study selection process was documented via a PRISMA 2020 flow diagram, detailing the number of records identified, screened, excluded (with reasons), and included. All included articles were available in full text; therefore, no studies available only in abstract form were included in the review.

Data Extraction:

We developed and used a standardized data extraction form. Two reviewers independently extracted data on study characteristics (author, year, country, study design), participant demographics, sample size, definitions and measurements of anaemia and handgrip strength, effect estimates (e.g., mean differences, odds ratios), adjustment for confounding variables, funding sources, and conflicts of interest. Any discrepancies in data extraction were resolved through discussion.

Assessment of Risk of Bias:

The risk of bias for each included study was assessed independently by two reviewers via the Joanna Briggs Institute (JBI) critical appraisal checklists appropriate for the study design (e.g., cross-sectional, cohort, case–control, RCT). (Supplementary File) The JBI critical appraisal tool includes structured questions to assess selection bias, measurement bias, confounding, and reporting bias. All judgments were documented, and disagreements were resolved through discussion or consultation with a third reviewer. We assessed the overall quality and certainty of evidence via established frameworks aligned with systematic review standards. Factors such as study design, risk of bias, consistency, directness, and precision were considered. Where applicable, subgroup analyses were planned by age group, sex, and health status to explore potential sources of heterogeneity and to improve the interpretability of pooled estimates. Each study was rated as having a low, moderate, or high risk of bias. Any disagreements were resolved by discussion or with input from a third reviewer.

Statistical analysis:

All the statistical analyses were conducted via R (version 4.3.0) with the meta package. In accordance with the registered protocol, a random-effects meta-analysis was performed where appropriate. Adjusted odds ratios (ORs) and 95% confidence intervals for the association between anaemia and weak handgrip strength were extracted. Heterogeneity was assessed via the I^2 statistic. Forest plots were used to visualize the effect estimates across studies. Owing to insufficient reporting across studies, planned subgroup and meta-regression analyses were not feasible.

Results

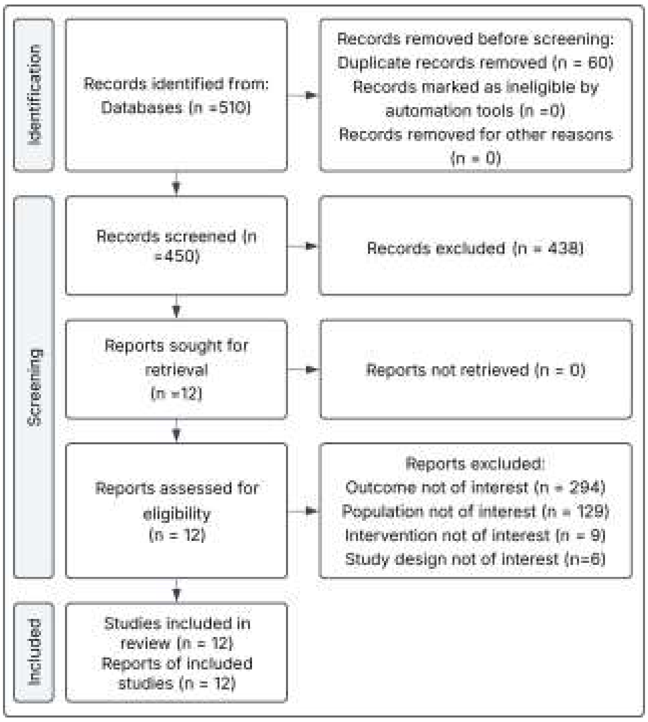
Study Selection:

A total of 510 records were identified through electronic database searches. Following the removal of duplicates (n=60), 450 records were screened by title and abstract. Of these, 438 studies were excluded because they did not meet the eligibility criteria. The full texts of 12 studies were retrieved and assessed, all of which met the inclusion criteria. The study selection process is detailed in Figure 1.

Study characteristics:

The review included 12 studies with 50,045 participants and sample sizes ranging from 118 to 24,022. Studies were conducted in Australia, Indonesia, Korea, and Singapore (two each) and Brazil, Germany, Saudi Arabia, and the United States (one each). Seven studies were cross-sectional, one was a population-based cohort, three used secondary data, and one was cross-sectional longitudinal. Three studies involved 2,102 participants aged ≥65 years, six included 4,938 participants aged ≥60 years, and one in Australia included 640 women aged 18–49 years. A longitudinal study in Australia involved 1,705 men aged ≥70 years, whereas two Korean studies included 24,022 participants aged ≥30 years and 16,638 aged >19 years.

Figure 1:
PRISMA Chart of the study selection process



Handgrip strength measurement:

Handgrip strength (HGS) was consistently measured via validated dynamometers, although the specific devices used varied. The JAMAR hydraulic dynamometer was employed in three studies, whereas the Smedley spring-type dynamometer was used in the study by Sutandyo et al.[12] Four studies utilized a Takei A5401 digital dynamometer (Japan). One study used an electronic dynamometer (CAMRY EH101; Almari & Simbawa[13]), and another used SAEHAN SH5001 hydraulic device.[14] Two studies did not specify the make or model of the device used. Definitions of low handgrip strength vary across studies. The most commonly applied cutoff was <28 kg for men and <18 kg for women, as seen in the studies by Sutandyo et al.[12], C.-T. Lee et al.[15], and Vanda Ho et al[16]. Lower thresholds were also reported, including <27 kg (men) and <16 kg (women) by Almari & Simbawa[13], <26 kg and <16 kg by Yu-mi Gi et al.[11], and <26 kg (men) by Hirani et al.[8] [Supplementary File 1, Table 1]

Haemoglobin estimation:

Haemoglobin was estimated via a variety of validated laboratory methods across the included studies. Hammer et al.[17] measured haemoglobin via photometry, reporting a reference range of 4.4–11.3 giga/L. Sutandyo et al.[12] and MacLean et al.[18] used

Figure 2:

Association of anaemia with hand grip strength (pooled analysis of three studies including the combined overall effect of Amaral et al.[14])

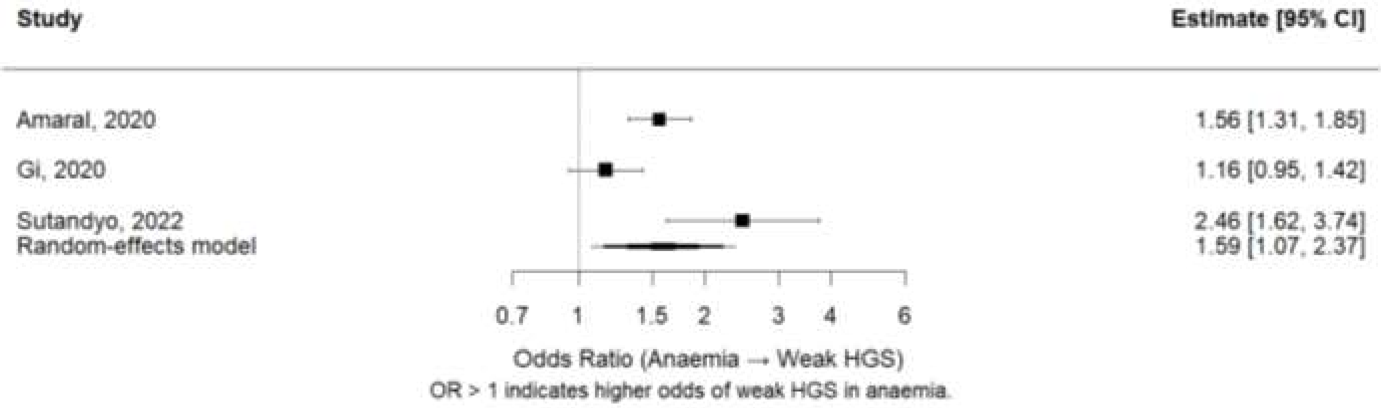


Figure 3:

Association between anaemia and weak handgrip strength: sensitivity analysis (Amaral et al.[14] men and women separated).

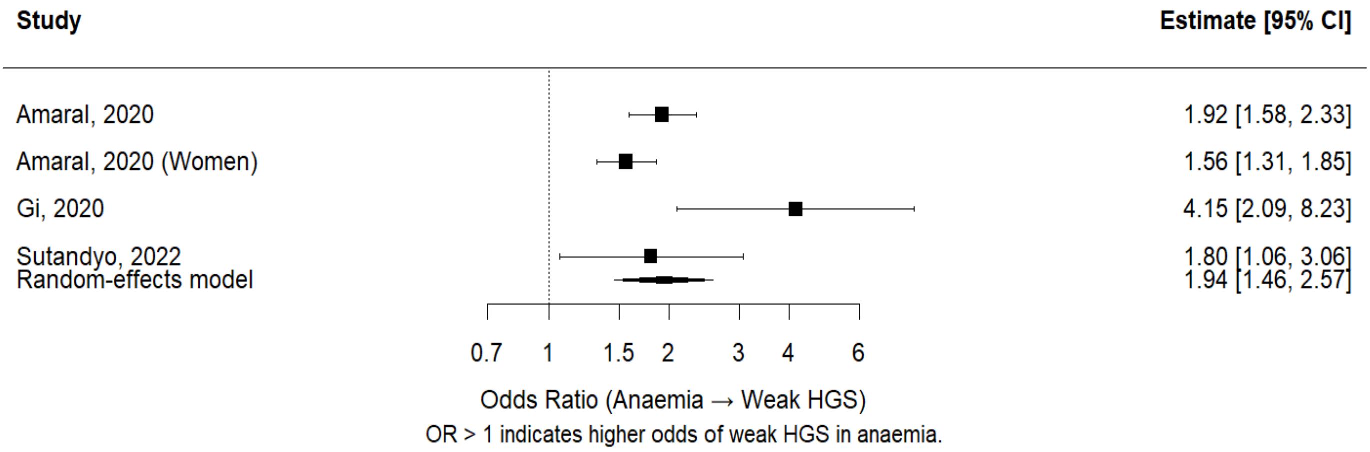
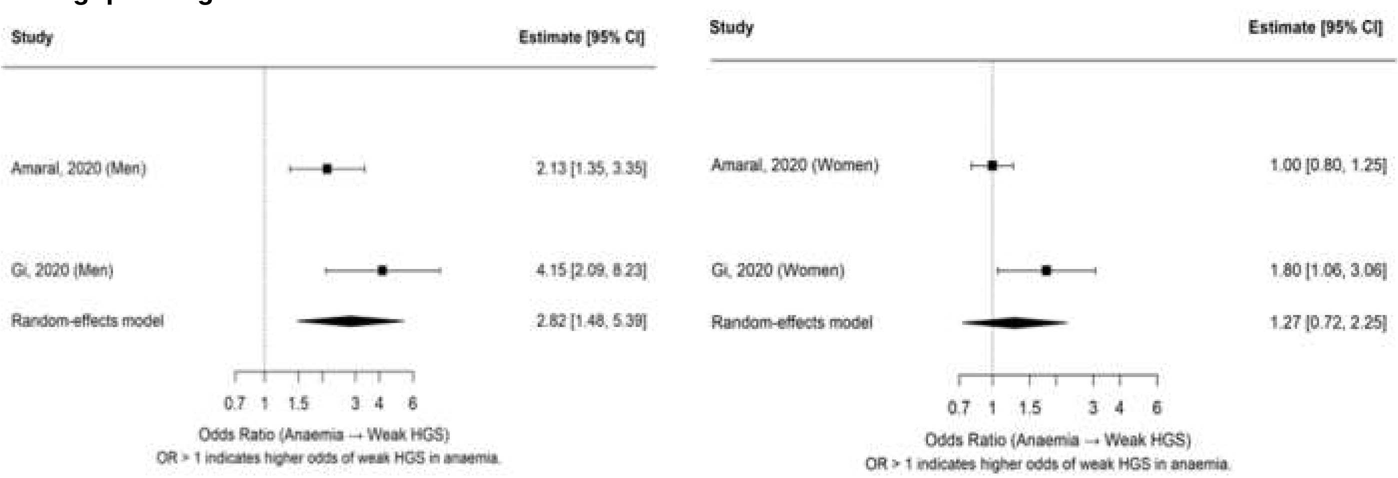


Figure 4:

4a) pooled association between anaemia and weak grip among Men 4b) pooled association between anaemia and weak grip among Women



HemoCue analysers, with the latter applying a threshold of <13 g/dL for defining anaemia. Among the twelve studies, eight adhered to the World Health Organization (WHO) criteria for defining anaemia, with cutoffs of <13 g/dL in men and <12 g/dL in women. The remaining studies employed either study-specific thresholds or additional biochemical markers, such as serum ferritin and transferrin saturation, to define anaemia status.

Association between Handgrip Strength and Anaemia:

Across individual studies, HGS consistently decreased with anaemia, although effect sizes and levels of statistical significance varied. Among the 328 older adults in the US studied by Stauder and Thein[19], participants with anaemia had significantly lower grip strength than did those without anaemia (21.3 vs. 24.1 kg, p=0.014) and reported greater fatigue, disability, and depressive symptoms. In an Indonesian study by Hidayat G et al.[20], mild anaemia in women was associated with weaker grip strength (β=3.17, p=0.008). In Hirani V et al.[8]'s study of Australian men aged 70 years and older, higher Hb levels were strongly associated with stronger grip strength, a reduced risk of sarcopenia, and better functional outcomes, with an adjusted β of 0.82 (95% CI 0.55–1.08) per g/dL increase. A Brazilian household survey of 1,016 older adults conducted by Amaral C et al.[14] revealed that anaemia conferred more than a fourfold increase in the odds of weak grip in men (aOR 4.15, 95% CI 2.09–8.21) and nearly a twofold increase in women (aOR 1.80, 95% CI 1.06–3.06), independent of body mass index and other covariates. In the large Korean KNHANES dataset (n=16,638), anaemia was associated with weak handgrip strength (OR 1.92, 95% CI 1.58–2.33), with a stronger effect in men (OR 2.13, 95% CI 1.35–3.34) and in participants aged 65 years or older (OR 1.92, 95% CI 1.42–2.58).[11] A Singaporean cohort of community-dwelling older adults (n=480) revealed that anaemia was significantly associated with frailty and lower grip strength; each 1 g/dL increase in haemoglobin was associated with a 6% reduction in the odds of frailty.[15] Another Singaporean study, the HOPE cohort (n=477), demonstrated that higher haemoglobin, ferritin, and transferrin saturation were independently associated with greater grip strength, whereas elevated hsCRP was inversely associated with greater grip strength.[16] An Indonesian multiprovince study of 3,192 older adults conducted by Sutandyo N. et al.[12] revealed a positive correlation between haemoglobin and grip strength (r=0.35, p<0.001) and an increased risk of weak grip strength in those with anaemia (OR 1.56, 95% CI 1.31–1.85), with the strongest associations among individuals aged 80 years and older. Lee BJ et al[10] reported that more than 24,000 Korean adults reported lower mean grip strength in anaemic participants than in their nonanemic counterparts, with adjusted odds ratios indicating a stronger effect in men than in women. A Saudi Arabian hospital-based study by Almari S & Simbawa M[13] of 135 participants revealed that low haemoglobin and malnutrition were independent predictors of reduced grip strength. A German cohort study (n=1,294) by Hammer T. et al.[14] demonstrated that the association between haemoglobin and grip strength was evident in women younger than 80 years and in men with ferritin concentrations ≥300 µg/L but absent in those over 80 years. MacLean B et al.[18] studied Australian reproductive-aged women (n=640) and confirmed that haemoglobin and ferritin levels were positively associated with grip strength, extending the relevance of this association to younger populations. The study-specific findings are presented in Supplementary File 1, Table 2.

Quantitative Synthesis:

Three independent estimates were eligible for quantitative pooling because they provided comparable effect measures (odds ratios with corresponding confidence intervals or sufficient raw data) for the association between anaemia and weak handgrip strength. In the primary meta-analysis, the sex-specific strata from Amaral et al.[14] (2020) were combined using inverse-variance weighting to generate a single overall estimate. Together with estimates from Gi et al.[11] (2020) and Sutandyo et al.[12] (2022), the pooled analysis showed that anaemia was associated with increased odds of weak handgrip strength (OR 1.59, 95% CI 1.07–2.37). Between-study heterogeneity was considerable (I^2 = 88.0%; τ^2 = 0.1047; Q = 11.63, df=2). Importantly, all three study-level estimates showed a consistent direction of effect, indicating higher odds of weak grip strength among participants with anaemia (Figure 2). The remaining included studies were not pooled because they lacked sufficient quantitative data, used different outcome definitions or reporting formats, or did not provide effect estimates suitable for meta-analysis.

In a sensitivity analysis, the male and female strata from Amaral et al.[14] (2020) were retained as separate estimates, resulting in four pooled effects. The association remained robust and slightly stronger (OR 1.94, 95% CI 1.46–2.57). The heterogeneity decreased but remained substantial (I^2 = 71.1%; τ^2 = 0.0509; Q = 8.69, df = 3) (Figure 3). This demonstrates that the findings were not an artifact of combining sex-specific estimates and confirms the stability of the association across analytic choices.

Subgroup analyses by sex were possible via data from Gi et al.[11] (2020) and Amaral et al.[14] (2020). Among men, anaemia was associated with markedly greater odds of weak grip strength (pooled OR 2.82, 95% CI 1.48–5.39), with moderate heterogeneity (I^2 = 60.6%; τ^2 = 0.1348; Q = 2.54, df = 1) (Figure 4a). In contrast, the pooled analysis for women suggested a weaker association (OR 1.27, 95% CI 0.72–2.25), accompanied by substantial heterogeneity (I^2 = 75.1%; τ^2 = 0.1297; Q = 4.01, df = 1) (Figure 4b). These divergent patterns suggest potential effect modification by sex, although the small number of available studies limits confidence in this interpretation. Assessment of small-study effects was not undertaken, in line with the Cochrane guidelines, given the inclusion of fewer than ten studies.

Taken together, the evidence from the available observational datasets consistently indicates that anaemia is associated with reduced muscle strength, measured objectively by handgrip strength testing. The primary and sensitivity analyses revealed higher odds of weak grip among individuals with anaemia, with the strongest and most consistent effects observed in men. Findings in women were less consistent and more heterogeneous. Studies incorporating biochemical indices of iron status (e.g., Ho et al.[16], 2022; Hammer et al.[17], 2024; MacLean et al.[18], 2024) further strengthen biological plausibility, showing positive associations of ferritin and transferrin saturation with grip strength and inverse associations for CRP.

Although substantial heterogeneity existed across studies, it likely stemmed from real differences in populations, protocols, and definitions rather than random noise. The effect direction remained consistent, with no contrary findings, strongly supporting anaemia as an independent driver of reduced muscle strength most clearly in men. These results emphasize incorporating anaemia screening into sarcopenia and frailty prevention, alongside calls for standardized methods and longitudinal research on age and sex-specific mechanisms.

A formal GRADE certainty assessment was not conducted. As all included studies were observational (cross-sectional or cohort designs) and generally judged at serious risk of bias, the certainty of evidence for all outcomes would begin at “low” and be further downgraded for risk of bias, inconsistency, and imprecision. Accordingly, overall certainty was considered “very low,” and no GRADE evidence table was presented.

Discussion

A consistent association between anaemia and reduced handgrip strength (HGS) was observed across the included observational studies involving more than 50,000 participants. Individuals with anaemia generally demonstrated lower HGS compared to non-anaemic participants. The meta-analysis of three studies indicated increased odds of weak HGS among participants with anaemia. Several studies, including those by Stauder & Thein[19], Hidayat et al.[20], and Amaral et al.[14], also reported associations between anaemia and fatigue, disability, and poorer functional status, particularly in older adults. Although some studies suggested stronger associations in men and older age groups, these findings should be interpreted cautiously because subgroup observations were derived from a limited number of studies and substantial heterogeneity was present across study populations and methodologies.

In addition to demographic and lifestyle factors, several blood biomarkers were significantly associated with HGS. Biochemical markers, such as elevated CRP, reduced lymphocyte count, and increased blood urea nitrogen, creatinine, and HbA1c, are associated with reduced muscle strength. Longitudinal data from the CHAMP cohort revealed that higher haemoglobin levels predict stronger HGS and better physical function.[21] This relationship extends to younger populations, as seen in reproductive-age women, indicating anaemia’s impact across the life course. Iron profile parameters, particularly ferritin and transferrin saturation (TSAT), have been reported as associative factors.[16-18]

The biological plausibility of these associations is supported by the pathophysiology of anaemia. Reduced haemoglobin levels impair the oxygen-carrying capacity of blood, thereby limiting oxygen delivery to muscles and compromising their functional performance. This mechanism explains the frequent observation of reduced physical performance in anaemic individuals, including slower walking speed, increased fatigue, and a greater prevalence of depressive symptoms.[19]

Anaemia also becomes more prevalent with advancing age, particularly among older adults. In line with this, nine of the twelve included studies specifically recruited participants aged 60 years and above.[19] Frailty, another age-related condition, is common in this population and may act as a potential confounding factor in the association between anaemia and HGS.[21] Evidence from studies on red cell distribution width (RDW), a marker of erythrocyte size variation, further supports this complexity. A higher RDW was associated with lower grip strength, particularly in older men, and this relationship persisted even among nonanemic individuals.[22] These findings suggest that factors other than anaemia may contribute to reduced muscle strength. In addition, many studies have attempted to establish the association between low hand grip strength and mortality risk.[23–25] On the other hand, a low hand grip strength association was established with metabolic health in children and adolescents. Moreover, studies have shown that low hand grip strength is associated with increased hospitalization and quality of life.[22]

Heterogeneity in HGS assessment tools, such as the JAMAR and Takei A5401 dynamometers, along with varying HGS thresholds and anaemia definitions, has contributed to substantial variability across studies. The observational design introduced risks of bias and confounding, with associations weakening in the oldest-old individuals or varying with iron status. The lack of a universal HGS cutoff complicates interpretation, as it varies by demographic and clinical factors. Future research is warranted to address the comparability of data obtained via different assessment tools.

Longitudinal studies are needed to establish temporality, whereas interventional trials should test whether correcting anaemia improves HGS and related outcomes. Mechanistic studies could clarify the roles of haemoglobin, iron availability, and inflammation. Standardizing HGS measurement tools and thresholds would enhance comparability. Integrated screening strategies combining HGS with haematological testing could improve clinical and public health surveillance. Further exploration of the links between low HGS and metabolic health in younger populations and hospitalization risk could broaden the health implications of HGS.

Conclusion

In conclusion, anaemia's strong link to reduced HGS highlights its role as a modifiable risk factor for muscle dysfunction, frailty, and poor quality of life across different populations. Integrating HGS as a simple, low-cost, non-invasive screening tool can improve anaemia detection and management. HGS may serve as a simple functional assessment measure associated with anaemia and reduced muscle strength. Given its ease of use and low cost, it could support functional health assessment in community and primary healthcare settings, particularly in resource-limited populations. Further longitudinal and interventional studies at different age group are needed to better understand its clinical utility and relationship with anaemia-related outcomes.

Given the observed association between anaemia and reduced handgrip strength (HGS), HGS may serve as a simple and non-invasive functional assessment tool in community and primary healthcare settings. Its ease of use and minimal equipment requirements could support early identification of individuals at risk of poor functional and nutritional health, particularly in resource-limited settings. Standardizing HGS protocols could position India as a leader in cost-effective surveillance, easing chronic disease burdens in elderly and underserved groups through scalable, equitable early interventions.

Declaration

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Conflict of Interest: No conflicts of interest are declared.

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