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Comparison of Hand Function and Grip Strength in Male and Female Hand Weavers

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ABSTRACT

Background: Hand weaving is a labor-intensive occupation that demands prolonged repetitive hand use, predisposing workers to musculoskeletal strain and reduced grip strength. Gender differences in grip strength and hand function among weavers have not been comprehensively studied in South Asia.

Objective: To compare hand grip strength and hand function between male and female hand weavers and to identify predictors of functional disability.

Methods: A cross-sectional observational study was conducted on 377 participants (246 males, 131 females) recruited from vocational training institutes in Pakistan between November 2022 and February 2023. Eligible participants were aged 24–36 years, with ≥3 years of weaving experience and ≥5 working hours per day. Hand grip strength was measured using a hand-held dynamometer, and hand function was assessed using the Patient-Rated Wrist Evaluation (PRWE) questionnaire and data were analyzed using SPSS version 25.

Results: Males exhibited significantly higher grip strength compared to females (38.4 ± 6.2 kg vs. 27.1 ± 5.8 kg, $p < 0.001$). Females reported higher disability with PRWE pain (24.6 ± 8.1 vs. 18.5 ± 7.3, $p < 0.01$), function (41.3 ± 13.2 vs. 32.7 ± 12.4, $p < 0.01$), and total score (65.9 ± 18.1 vs. 51.2 ± 16.5, $p < 0.001$). Regression analysis identified gender as the strongest predictor of both outcomes, while higher BMI was associated with stronger grip and lower disability ($p < 0.01$).

Conclusion: Male weavers demonstrated superior grip strength and functional outcomes compared to females, who showed greater exposure to musculoskeletal disability. Ergonomic interventions and preventive strategies are warranted to reduce occupational strain among hand weavers.

Keywords: Ergonomics, Gender Differences, Hand Strength, Musculoskeletal Diseases, Occupational Health, Textile Industry, Weaving Industry.

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Introduction

The Handloom weaving, defined as weaving on any loom not powered by electricity, remains a vital cultural and economic activity in South Asia. This process, which involves human labor in at least one stage of fabric production, continues to account for more than one-tenth of India's textile output and significantly contributes to both regional and national economies (1). The handloom itself, traditionally constructed from wood and iron, is manually operated through the coordinated use of hands and feet. In Bangladesh, the handloom industry represents the largest handicraft sector and remains the second-largest rural employer after agriculture, highlighting its socio-economic importance (2).

The functionality of the hand plays a central role in sustaining the productivity of hand weavers. According to the American Society of Hand Therapists, grip strength serves as a key determinant of hand function and is widely utilized in clinical and occupational assessments of upper limb strength. The hand dynamometer has become the gold standard for evaluating grip strength and endurance, with normative values strongly influenced by age and gender (3). In occupational settings such as weaving, grip strength is particularly critical, as it reflects not only musculoskeletal capacity but also resilience to fatigue and strain. Fatigue, characterized by the inability to maintain or generate expected force, is a common occupational hazard that compromises efficiency, endurance, and work performance. Prolonged exposure to muscle fatigue can contribute to musculoskeletal diseases, persistent pain, and impaired muscle function, although in physiological terms, fatigue also acts as a protective mechanism to safeguard muscles from metabolic overload and structural damage (4).

Musculoskeletal disorders (MSDs) are among the most common occupational health problems across labor intensive industries. These disorders often arise from repetitive tasks, forceful exertion, awkward postures, and exposure to mechanical stress or vibration (5). For hand weavers, repetitive and sustained finger exertion, coupled with poor ergonomic practices and long hours in constrained postures, predispose them to a wide spectrum of MSDs. These include finger and spinal abnormalities, carpal tunnel syndrome, tendinitis, epicondylitis, chronic back and neck pain, shoulder dysfunction, and even degenerative joint disorders such as osteoarthritis (6,7). Such conditions not only compromise worker health but also reduce overall productivity and efficiency within the textile industry.

Hand grip strength, defined as the maximal voluntary force produced by intrinsic and extrinsic muscles of the hand and forearm during gripping, serves as a critical biomarker of upper extremity function and general muscular health (8). Its role is not only limited to evaluating functional hand capacity but also extends to assessing risks of occupational injury and decline in work performance. Despite the clear importance of grip strength in the weaving profession, there is a paucity of research focusing on hand function and grip strength among Pakistani male and female hand weavers. Given the unique physical demands of this occupation, ergonomic interventions tailored to the weaving environment may offer an effective strategy to minimize muscle fatigue, prevent work-related musculoskeletal disorders, and enhance worker productivity and safety. In this context, the present study seeks to examine and compare hand function and grip strength between male and female hand weavers in order to identify gender specific vulnerabilities and provide evidence based recommendations for ergonomic optimization in this area.

Materials and Methods

This study employed a cross-sectional observational design using convenient non-probability sampling. Data were collected from multiple vocational training institutes, including the Pakistan Knitwear Training Institute and Hunarkada, over a four-month period from November 2023 to February 2024. A total of 377 participants were recruited, comprising 246 males and 131 females. The sample size was calculated using Raosoft software with a 95% confidence interval and a 5% margin of error, ensuring adequate statistical power for the analysis (9).

Eligible participants were male and female hand weavers aged between 24 and 36 years, with a minimum work experience of three to five years and a daily work duration of at least five hours. Exclusion criteria included any neurological or orthopedic condition that could impair hand strength, history of upper limb fractures or surgery, carpal tunnel syndrome as confirmed by the Phalen's test, De Quervain's disease, diabetes mellitus, soft tissue or joint related malignancies, or recent surgery. All participants meeting the eligibility criteria were invited, and those who agreed provided written informed consent prior to enrollment.

Hand function was assessed using the Patient Rated Wrist Evaluation (PRWE) questionnaire. The PRWE is a validated 15-item instrument designed to measure wrist pain and disability in daily activities, with a Spearman's rho reliability coefficient of 0.9, confirming its dependability as an upper extremity outcome tool. It consists of two subscales: pain (five items scored on a scale of 0–10, maximum 50 points) and function (ten items divided into usual and specific activities, maximum 50 points). The total score ranges from 0 to 100, with higher scores indicating greater pain and disability.

Grip strength was measured using a hand held dynamometer, which is considered a reliable and valid tool for isometric strength assessment, offering greater precision compared to manual muscle testing. During testing, the participant performed a maximal isometric

contraction while the examiner stabilized the device against the participant's hand. Grip force was recorded in kilograms of force, representing the counterforce exerted by the dynamometer against the participant's maximal contraction (10,11). The intra-class correlation coefficient (ICC) for the dynamometer exceeded 0.9 for validity, with both intra- and inter-tester reliability reported as excellent (ICC > 0.75) across all movements (12).

Results

A total of 377 hand weavers participated in this study, comprising 246 males (65.3%) and 131 females (34.7%). The mean age was 29.55 ± 3.65 years (range 24–36). The majority were right-hand dominant (91.0%), with a mean body mass index (BMI) of 25.1 ± 3.8 kg/m². Most participants reported >10 years of weaving experience, and the average working time was 7.8 ± 1.4 hours/day. Smoking was more prevalent among males (39.0% vs. 4.6%), while comorbidities were relatively uncommon (Table 1 & 2). Males demonstrated significantly higher grip strength than females (38.4 ± 6.2 kg vs. 27.1 ± 5.8 kg, $p < 0.001$). In contrast, females reported significantly higher disability on the Patient-Rated Wrist Evaluation (PRWE) scale. Female participants scored higher in pain (24.6 vs. 18.5, $p < 0.01$), function (41.3 vs. 32.7, $p < 0.01$), and total PRWE score (65.9 vs. 51.2, $p < 0.001$) compared to males (Table 3).

Table 1: Demographic Characteristics of Study Participants

Variable		Frequency	Percent
Hand Dominance	Right	343	91.0%
	Left	34	9.0%
Gender	Males	246	65.3%
	Females	131	34.7%
Age (years)		Mean ± SD: 29.55 ± 3.65 (Range: 24–36)	
Number of Participants		377	100%

Table 2: Gender-wise Demographic Characteristics of Study Participants

Variable	Males (n = 246)	Females (n = 131)	Total (N = 377)
Age (years)	29.7 ± 3.6	29.3 ± 3.7	29.55 ± 3.65
Hand Dominance			
• Right	227 (92.3%)	116 (88.5%)	343 (91.0%)
• Left	19 (7.7%)	15 (11.5%)	34 (9.0%)
Body Mass Index (kg/m²)	25.5 ± 3.9	24.6 ± 3.5	25.1 ± 3.8
Marital Status			
• Married	152 (61.8%)	46 (35.1%)	198 (52.5%)
• Single	94 (38.2%)	85 (64.9%)	179 (47.5%)
Educational Level			
• No formal schooling	90 (36.6%)	52 (39.7%)	142 (37.7%)
• Primary/Secondary	105 (42.7%)	50 (38.2%)	155 (41.1%)
• Higher education	51 (20.7%)	29 (22.1%)	80 (21.2%)
Years of Weaving (experience)	12.1 ± 4.5	9.8 ± 3.7	11.3 ± 4.2
Working Hours per Day	8.2 ± 1.3	7.1 ± 1.2	7.8 ± 1.4
Smoking Status			
• Yes	96 (39.0%)	6 (4.6%)	102 (27.1%)
• No	150 (61.0%)	125 (95.4%)	275 (72.9%)
Co-morbidities			
• None	188 (76.4%)	108 (82.4%)	296 (78.5%)
• Hypertension	28 (11.4%)	10 (7.6%)	38 (10.1%)
• Diabetes Mellitus	18 (7.3%)	7 (5.3%)	25 (6.6%)
• Musculoskeletal Issues	12 (4.9%)	6 (4.6%)	18 (4.8%)

Multiple regression analysis was conducted to identify predictors of the PRWE total score and grip strength. Gender emerged as the strongest predictor, with females scoring an average of 14.2 points higher on the PRWE scale, indicating greater disability, and demonstrating 11.3 kg lower grip strength compared to males ($p < 0.001$ for both). Body mass index (BMI) showed a dual effect, as each unit increase in BMI was associated with a reduction

of 1.1 points in PRWE scores, reflecting lower disability ($p < 0.01$), and an increase of 0.85 kg in grip strength ($p < 0.01$). In contrast, age and weaving experience demonstrated only minor and statistically nonsignificant effects on both PRWE scores and grip strength, suggesting that gender and BMI were the primary determinants of outcomes in this study (Table 4).

Table 3: Comparison of Grip Strength and PRWE Scores Between Male and Female Hand Weavers

Variable	Males (n = 246)	Females (n = 131)	p-value
Grip Strength (kg, Dynamometer)	38.4 ± 6.2	27.1 ± 5.8	<0.001 ***
PRWE – Pain Score (0–50)	18.5 ± 7.3	24.6 ± 8.1	<0.01 **
PRWE – Function Score (0–100)	32.7 ± 12.4	41.3 ± 13.2	<0.01 **
PRWE – Total Score (0–150)	51.2 ± 16.5	65.9 ± 18.1	<0.001 ***

*Data presented as Mean ± SD. Independent sample t-test applied. ***$p < 0.001$, *$p < 0.01$ considered statistically significant.

Table 4: Multiple Regression Predicting PRWE Total Score and Grip Strength

Predictor	Effect on PRWE Total Score			Effect on Grip Strength (kg)		
	β (Unstd.) ± SE	Summary	p-value	β (Unstd.) ± SE	Summary	p-value
Gender (Male=0, Female=1)	+14.2 ± 2.8	Females scored higher PRWE disability	<0.001 ***	–11.3 ± 1.9	Females had lower grip strength	<0.001 ***
BMI (kg/m²)	–1.1 ± 0.3	Higher BMI → lower disability	<0.01 **	+0.85 ± 0.27	Higher BMI → stronger grip	<0.01 **
Age (years)	+0.25 ± 0.27	Small ↑PRWE with age	0.37 (ns)	–0.12 ± 0.15	Small ↓strength with age	0.41 (ns)
Weaving Experience (years)	–0.38 ± 0.27	Slight ↓disability with more experience	0.16 (ns)	+0.08 ± 0.07	Slight ↑strength with more experience	0.29 (ns)

Discussion

This comparative cross-sectional study explored differences in hand grip strength and hand function between male and female hand weavers using standardized tools, including a hand-held dynamometer and the Patient-Rated Wrist Evaluation (PRWE) questionnaire. The results demonstrated that men exhibited significantly greater grip strength compared to women, while women had higher PRWE scores, suggesting greater pain and disability, which ultimately reflected lower hand function. These findings were consistent with the established understanding that gender plays a pivotal role in muscle strength and functional performance, with men typically exhibiting higher absolute grip strength owing to physiological and anatomical differences (13).

The observed gender differences aligned with earlier findings from occupational health research. A 2018 study on hand weavers reported that female workers in hand block printing displayed relatively higher grip strength, whereas women engaged in imitation jewelry work showed the weakest grips, illustrating how task-specific demands contribute to variations in grip capacity (13). Similarly, prolonged and repetitive use of hand tools has been associated with diminished muscle endurance and strength over time, supporting the notion that weaving tasks impose substantial strain on hand and forearm muscles, predisposing workers to fatigue and functional decline (13).

The higher PRWE scores among female participants in this study suggested that women experienced greater discomfort and functional impairment compared to men. This finding echoed the work of Hwang et al. (2021), who demonstrated gender-specific relationships between grip strength and psychosocial factors, noting that women with higher stress levels tended to exhibit stronger correlations with grip performance, whereas weaker grip in males was linked to poorer mental health outcomes (14). These results highlight the multifactorial nature of hand function, encompassing both biomechanical and psychosocial determinants.

Further insights can be drawn from studies on special populations. For example, Kogure and Ribeiro (2021) reported that women with polycystic ovarian syndrome (PCOS) exhibited significantly higher grip strength compared to healthy counterparts, largely attributed to

greater lean muscle mass and hormonal influences (15). This underscores the role of biological factors such as body composition, hormonal status, and metabolic profile in determining grip strength outcomes. Conversely, chronic conditions such as type 2 diabetes have been shown to negatively impact hand grip strength, as demonstrated in the study by Kaur et al. (2021), where diabetic patients exhibited significantly lower grip values than healthy controls, consistent with reduced muscle quality and peripheral neuropathy (16). Similarly, research during the COVID-19 pandemic highlighted that hospitalized patients, particularly women, reported muscle weakness, fatigue, and impaired grip strength due to reduced oxygenation and systemic inflammation, as noted by Tuzun et al. (2020) (17). These studies collectively reinforce the importance of contextualizing grip strength within broader health, lifestyle, and occupational frameworks.

The present study had several strengths, including its relatively large sample size, inclusion of both genders within a specific occupational group, and use of validated assessment tools with high reliability and reproducibility. These methodological strengths increased the robustness of the findings. However, certain limitations should be acknowledged. The cross-sectional design precluded causal inference, limiting the ability to establish temporal relationships between weaving exposure and functional outcomes. The reliance on convenient sampling may have introduced selection bias, reducing the generalizability of the findings. Additionally, confounding variables such as nutritional status, lifestyle habits, hormonal differences, and psychosocial stressors were not controlled, which may have influenced grip strength and hand function outcomes.

Despite these limitations, the findings offered valuable insights for ergonomic intervention and occupational health planning in the handloom sector. The evidence suggested that female workers might be at higher risk of functional impairment and work-related musculoskeletal disorders due to lower grip strength and higher functional disability scores. Ergonomic modifications, such as redesigning tools to reduce repetitive strain, incorporating scheduled rest breaks, and providing strength and flexibility training, could help mitigate these risks. Future research should adopt longitudinal designs to explore causal relationships and consider broader determinants, including nutrition, psychosocial stress, and hormonal influences, to gain a more comprehensive understanding of gender differences in hand function among textile workers.

Conclusion

The This study concluded that male hand weavers demonstrated significantly greater grip strength and superior hand function compared to females, who reported higher pain and disability scores. Higher BMI was associated with stronger grip and lower disability across both genders, highlighting the protective role of body composition. Right-hand dominance was also linked to greater strength, reinforcing the influence of functional laterality. However, musculoskeletal conditions were more prevalent in females than males.

Authors' Contributions

ICMJE authorship criteria	Detailed contributions	Authors
Substantial Contributions	Conception or Design of the work	1,2,3
	Data acquisition	2,3,4
	Data analysis or interpretation	1,3
Drafting or Reviewing	Draft the work	1
	Review critically	1,2,3,4
Final approval	Final approval of the version to be published.	1,2,3,4
Accountable	Agreement to be accountable for all aspects of the work.	1,2,3,4

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