

# Frequency of Upper Limb Functional Limitations Among Standing Passengers Holding Hand Rails

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## ABSTRACT

**Background:** Standing passengers in urban public transport commonly hold hand rails for balance during acceleration and deceleration, which may increase repetitive or sustained upper-limb loading and contribute to functional limitation. **Objective:** To determine the frequency of upper limb functional limitations among standing passengers holding hand rails during public transport travel in Lahore. **Methods:** A cross-sectional study was conducted at metro and Speedo bus stops and Orange Line stations in Lahore. Adults aged 18–35 years who had been traveling for at least six months and typically traveled standing while holding rails were recruited using convenience sampling. Upper-limb function was assessed using the Upper Extremity Functional Index (UEFI-15), and scores were categorized as lowest (<40), moderate (40–80), or highest (>80) functional status. Descriptive statistics were summarized as means, standard deviations, frequencies, and percentages. **Results:** A total of 270 participants were included (51.5% male, 48.5% female). Mean age was 25.67 ± 4.29 years. Mean UEFI-15 score was 55.64 ± 21.77. The frequency of lowest functional status was 28.9% (n=78), moderate functional status 47.0% (n=127), and highest functional status 24.1% (n=65). **Conclusion:** Most standing passengers holding hand rails demonstrated moderate upper-limb functional status, while nearly one-third showed low function, indicating a substantial burden of functional limitation in this commuting context. **Keywords:** Repetitive strain injuries; Upper limb; Upper Extremity Functional Index; Public transport; Standing passengers.

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## INTRODUCTION

Urban public transportation systems play a critical role in facilitating mobility for large populations; however, they also present potential ergonomic and musculoskeletal risks for commuters who frequently travel while standing. In densely populated cities of developing countries, overcrowding in buses and metro systems often forces passengers to remain standing for extended durations while holding overhead or vertical hand rails to maintain balance during transit. This sustained posture requires repetitive activation of the shoulder girdle, elbow flexors, and wrist stabilizers, which may contribute to mechanical strain and functional limitations in the upper extremities. Functional range of motion of the upper limb refers to the ability of joints and muscles to perform coordinated movements necessary for daily activities and maintaining independence in routine tasks (1).

Repetitive or sustained muscular loading of the upper limb has been widely recognized as a contributing factor to repetitive strain injuries (RSIs), also referred to as cumulative trauma disorders. These conditions arise from repetitive movements, prolonged static postures, or excessive loading of musculoskeletal structures such as tendons, ligaments, and peripheral nerves (2). Occupational and ergonomic research has shown that individuals engaged in repetitive hand activities—such as computer operators, assembly workers, and office employees—are at increased risk of developing upper extremity

musculoskeletal disorders, including tendinopathies, epicondylitis, and compressive neuropathies (3,4). These disorders often manifest as pain, weakness, reduced grip strength, paresthesia, and functional limitations affecting daily activities and work productivity (5).

Pathophysiological mechanisms underlying repetitive strain injuries involve microtrauma to soft tissues resulting from repeated mechanical stress. Over time, this stress can trigger inflammatory processes, neural sensitization, and fibrotic changes in muscles and connective tissues, leading to chronic pain and impaired function (6). Imaging studies have further demonstrated that repetitive loading can produce structural alterations in tendons and peripheral nerves, contributing to compressive neuropathies and tendon pathologies in the upper extremity (7). Although these injuries are commonly associated with occupational settings, similar biomechanical exposures may occur in non-occupational environments where individuals repeatedly maintain static gripping postures.

One such environment is public transportation, where passengers frequently grasp hand rails while standing to stabilize themselves during vehicle acceleration, deceleration, and turns. Maintaining overhead arm elevation or sustained gripping of rails for prolonged periods may increase muscular fatigue in the shoulder and forearm muscles, thereby predisposing individuals to repetitive strain injuries (8). Non-collision injuries among public bus passengers have been recognized as an important public health concern, particularly in urban transport systems where sudden movements of vehicles and overcrowding increase the physical load on standing commuters (9).

Despite the widespread use of public transportation in many metropolitan cities, research examining the musculoskeletal implications of prolonged standing and rail gripping during bus travel remains limited. Most existing studies have focused on occupational ergonomic exposures or traffic-related injuries rather than functional limitations arising from everyday commuting activities (10). Consequently, there is a lack of epidemiological data describing the prevalence or functional impact of upper limb strain among regular public transport users.

In Lahore, Pakistan, thousands of individuals rely daily on metro buses, Speedo buses, and the Orange Line train system for commuting. Overcrowding frequently compels passengers to stand and hold overhead rails for extended periods, potentially exposing them to repetitive mechanical stress on the upper extremities. However, empirical evidence documenting the functional consequences of this exposure among commuters remains scarce. Understanding the extent of upper limb functional limitations in this population is important for identifying potential ergonomic risks and informing preventive strategies in public transportation systems.

Therefore, the present study aimed to determine the frequency of upper limb functional limitations among standing passengers who regularly hold hand rails while traveling in public transportation systems in Lahore. The study specifically assessed upper limb function using the Upper Extremity Functional Index (UEFI-15) among young adult commuters aged 18–35 years who had been using public transport for at least six months. It was hypothesized that a considerable proportion of standing passengers would demonstrate moderate to low functional status due to repetitive strain associated with prolonged rail gripping during transit.

## **MATERIALS AND METHODS**

This cross-sectional observational study was conducted to determine the frequency of upper limb functional limitations among standing passengers holding hand rails while traveling in public transportation systems. The study was carried out at major public transport stations in Lahore, Pakistan, including Metro Bus stations, Speedo Bus stops, and Orange Line train stations. Data collection was conducted over a six-month period following approval of the study protocol.

The target population consisted of adult passengers who regularly used public transportation and traveled while standing during transit. Participants aged between 18 and 35 years who had been

commuting via public buses or metro services for at least six months were considered eligible for inclusion. Both male and female passengers who reported standing during travel and holding hand rails for support were included in the study. Individuals were excluded if they had a history of upper limb injury, congenital deformity of the upper extremity, previously diagnosed rheumatologic conditions such as rheumatoid arthritis or osteoarthritis, or neurological disorders affecting upper limb function. These exclusion criteria were applied to minimize confounding factors that could independently influence upper extremity functional status (11).

Participants were recruited using a convenience sampling approach at selected public transportation stations. The researcher approached passengers present at the stations and provided a brief explanation of the study objectives and procedures. Individuals who expressed willingness to participate were invited to complete the study questionnaire after providing informed consent. Participation was voluntary, and confidentiality of responses was ensured throughout the data collection process.

The primary outcome variable was upper extremity functional status, assessed using the Upper Extremity Functional Index-15 (UEFI-15). The UEFI-15 is a validated self-reported outcome measure used to evaluate functional limitations of the upper limb across a range of daily activities. The instrument consists of fifteen items assessing functional tasks involving the shoulder, elbow, and wrist. Each item is rated on a five-point scale ranging from extreme difficulty or inability to perform the activity (score = 0) to no difficulty (score = 3). Total scores are converted to an interval scale ranging from 0 to 100, where higher scores indicate better upper extremity function (12). The UEFI-15 has demonstrated good reliability, internal consistency, and construct validity in musculoskeletal research settings (12).

In addition to the functional index, demographic information including age and gender was collected from each participant. Age was recorded in completed years, and gender was categorized as male or female. For analytical purposes, UEFI scores were categorized into three functional status groups based on previously reported clinical thresholds: lowest functional status (<40), moderate functional status (40–80), and highest functional status (>80).

Sample size was estimated using the Cochran formula for cross-sectional studies with a 95% confidence interval and a margin of error of 5%. Assuming an estimated prevalence of upper limb functional limitations of 50% due to limited available data in the target population, the initial sample size calculation yielded a requirement of 384 participants. Because the accessible commuter population within the selected stations was considered finite, the sample size was adjusted using the finite population correction formula, resulting in a minimum required sample size of approximately 278 participants (13). A final sample of 270 participants was obtained during the study period.

Data collection was performed using a structured questionnaire comprising demographic information and the UEFI-15 instrument. Participants completed the questionnaire onsite under the supervision of the researcher to ensure completeness and accuracy. Completed questionnaires were reviewed for missing or inconsistent responses before inclusion in the dataset.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) software version 23. Continuous variables such as age and UEFI score were summarized using means and standard deviations, while categorical variables were reported as frequencies and percentages. The distribution of upper extremity functional status categories was analyzed descriptively to determine the frequency of functional limitations among participants. Associations between gender and functional status categories were evaluated using the chi-square test of independence. Statistical significance was determined at a p-value of less than 0.05.

Several measures were implemented to reduce potential sources of bias. Eligibility criteria were applied consistently during recruitment to minimize confounding factors related to pre-existing

musculoskeletal conditions. Standardized instructions were provided to participants before completion of the questionnaire to reduce measurement variability. Data entry accuracy was verified through double-checking procedures, and statistical analyses were conducted according to a predefined analysis plan to enhance reproducibility and transparency. Ethical approval for the study was obtained from the relevant institutional research ethics committee prior to commencement of data collection. All participants provided written informed consent before participation. The study adhered to established ethical principles for research involving human participants, including voluntary participation, confidentiality of data, and the right to withdraw from the study at any stage without penalty.

## RESULTS

Description: Participants were young adults with a mean age of  $25.67 \pm 4.29$  years (range 18–32). The mean UEFI-15 score was  $55.64 \pm 21.77$  (range 20–90), with a 95% CI of 53.03–58.25, indicating substantial variability in upper-limb function among standing passengers holding hand rails.

*Table 1. Participant Characteristics and Upper Extremity Function (n = 270)*

Variable	Minimum	Maximum	Mean	SD	95% CI (Mean)
Age (years)	18	32	25.67	4.29	25.16–26.18
UEFI-15 total score (0–100)	20	90	55.64	21.77	53.03–58.25

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*Table 2. Gender Distribution (n = 270)*

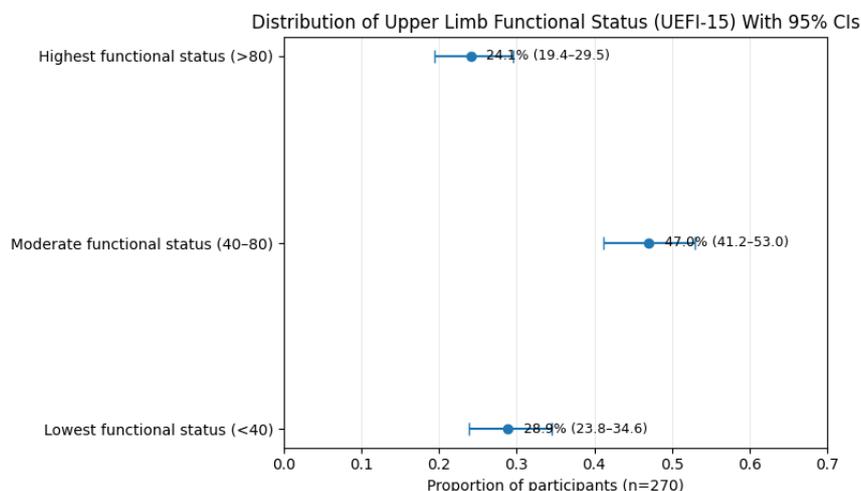
Gender	n	%	95% CI (Proportion)
Male	139	51.5	45.5–57.4
Female	131	48.5	42.6–54.5
Total	270	100.0	—

The sample was nearly balanced by gender, with 51.5% males and 48.5% females, and overlapping confidence intervals, suggesting no meaningful sampling skew toward either gender.

*Table 3. Frequency of Upper Limb Functional Status Categories (UEFI-15) (n = 270)*

UEFI-15 Category	Criteria	n	%	95% CI (Proportion)
Lowest functional status	< 40	78	28.9	23.8–34.6
Moderate functional status	40–80	127	47.0	41.2–53.0
Highest functional status	> 80	65	24.1	19.4–29.5
Total	—	270	100.0	—

Nearly half of participants had moderate functional status (47.0%), while 28.9% fell into the lowest function category and only 24.1% achieved highest function. This distribution suggests that roughly three-quarters (75.9%) of standing passengers holding rails did not fall in the highest-function band, supporting a clinically relevant burden of functional limitation in this commuting context.



*Figure 1 Distribution of Upper Limb Functional Status*

Figure 1 illustrates the distribution of upper limb functional status among standing passengers holding hand rails, measured using the Upper Extremity Functional Index (UEFI-15), with 95% confidence intervals (CIs) shown for each category. The horizontal axis represents the proportion of participants ( $n = 270$ ), while the vertical axis displays the three functional status categories derived from UEFI-15 score thresholds.

The largest proportion of participants fell into the moderate functional status category (40–80), accounting for 47.0% of the sample (95% CI: 41.2–53.0). This indicates that nearly half of the standing passengers experienced noticeable but not severe upper limb functional limitations. The second largest group was the lowest functional status category (<40), comprising 28.9% of participants (95% CI: 23.8–34.6), suggesting that more than one-quarter of commuters had substantial functional impairment in upper extremity activities. In contrast, only 24.1% of participants (95% CI: 19.4–29.5) demonstrated highest functional status (>80), reflecting relatively normal upper limb function.

The confidence interval bars provide an estimate of statistical precision around each proportion. Although the intervals for the lowest and highest categories partially overlap, the moderate functional category remains clearly the most prevalent, highlighting a central tendency toward intermediate functional limitation rather than normal function among standing passengers. Overall, the figure demonstrates that approximately three-quarters of the study population (75.9%) did not achieve the highest level of upper limb function, reinforcing the potential musculoskeletal burden associated with sustained hand-rail gripping during public transportation travel.

## DISCUSSION

Repetitive upper-limb loading from sustained gripping and prolonged shoulder elevation is a biologically plausible pathway for functional limitation in standing passengers, because repetitive or sustained mechanical stress can provoke microtrauma and maladaptive tissue responses in muscle-tendon units and peripheral nerves over time (5,6). In urban public-transport settings, standing passengers are additionally exposed to perturbations from acceleration, deceleration, and turning, which can increase gripping force demands and amplify cumulative upper-limb loading even in the absence of a collision event (9,14). Within this context, the present findings show that only 24.1% of standing passengers achieved high functional status on the UEFI-15, whereas 75.9% fell outside that band, with 47.0% demonstrating moderate function and 28.9% demonstrating low function. This distribution suggests a meaningful burden of functional compromise among routine commuters who rely on hand rails for stability, and it supports the study rationale that habitual rail-holding during daily travel may be associated with decreased upper-extremity function.

The observed functional profile aligns with prior epidemiologic evidence that symptoms and functional impairment in the upper extremities are common in populations exposed to repetitive or sustained upper-limb demands. In a cross-sectional study of bank workers, symptoms of the upper extremities and RSI-related conditions were prevalent and showed associations with demographic and occupational factors, highlighting that repetitive upper-limb exposure can translate into clinically relevant symptom and function burdens in working-age adults (17). Similarly, office-based studies have linked repetitive upper-limb demands and workplace-related factors to upper-extremity RSI occurrence, reinforcing that sustained and repetitive exposures may contribute to functional limitations in everyday activities (19). Although commuting exposures differ from occupational tasks, the common element—repetitive or sustained loading—supports a coherent interpretation that transport-related upper-limb demands may plausibly contribute to functional limitation patterns in young adults.

From a public health and health-systems perspective, these findings may be important because upper-limb repetitive strain disorders are not only common but can also carry substantial societal and economic consequences through healthcare use and productivity impacts, as demonstrated in compensation-claims and occupational injury analyses (18). While the current study did not test

causality or quantify exposure intensity (e.g., daily travel duration, grip posture type, or peak accelerations), the notable proportion of low functional status underscores the need for preventive strategies in mass-transit environments. Prevention efforts may include ergonomic rail design (diameter, texture, height options), stabilization supports that reduce sustained overhead abduction, and operational measures to reduce sudden vehicle dynamics, which have been discussed as components of injury-prevention strategies for non-collision injuries in urban buses (14).

Clinically, the study's reliance on the UEFI-15 provides a standardized functional snapshot, and the broad spread in scores is consistent with the instrument's utility across musculoskeletal presentations (16). However, interpretation should remain cautious because the study design is cross-sectional and based on self-reported function, without clinical examination or objective biomechanical exposure measurement. Future work should incorporate exposure quantification (e.g., travel duration per week, standing density, rail height relative to participant anthropometry), objective assessments (grip strength, provocative tests for compressive neuropathy), and analytic modeling that adjusts for confounders. Additionally, given experimental evidence that manual therapy and rest can modulate neuromuscular inflammation and fibrosis in overuse models, mechanistic and interventional research could explore feasible commuter-focused preventive or rehabilitative approaches for early symptoms in high-exposure passengers (10–12).

## CONCLUSION

Among standing public-transport passengers who routinely held hand rails, upper-limb function measured by the UEFI-15 was most commonly moderate (47.0%), while more than one-quarter demonstrated low functional status (28.9%) and only 24.1% demonstrated high functional status, indicating that a substantial proportion of commuters may experience clinically meaningful upper-extremity functional limitation in this daily travel context.

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