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Original Article

Prevalence and Determinants of Exercise-Associated Musculoskeletal Disorders in the Fitness Center Population: A Cross-Sectional Study from Karachi

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ABSTRACT

Background: Exercise offers substantial physical and psychological health benefits, yet participation in gym-based activities carries risks of musculoskeletal injury when performed without supervision or preventive practices. The global rise in fitness center participation has been paralleled by increasing injury incidence, but local data from Pakistan remain limited. Objective: To determine the prevalence and determinants of exercise-associated musculoskeletal disorders among gym members in Karachi, with emphasis on training practices and demographic risk factors. Methods: A descriptive cross-sectional study was conducted between January and May 2023 in multiple Karachi fitness centers. A total of 150 adults aged 18–45 years were recruited using convenience sampling. Data were collected through a structured questionnaire capturing demographics, training patterns, and injury history. Statistical analyses included chi-square tests, odds ratios with 95% confidence intervals, and multivariable logistic regression to identify independent predictors. Results: Injury prevalence was 25.3% (n = 38), with the lower limbs most frequently affected (7.3%). Weightlifting was the leading cause (12.7%) and remained a significant independent predictor (adjusted OR = 2.23, 95% CI: 1.25–3.97). Lack of supervision (OR = 1.94, p = 0.017), absence of warm-up (OR = 1.72, p = 0.039), gym experience ≥1 year (OR = 2.01, p = 0.028), and session duration >1 hour (OR = 1.76, p = 0.044) were also significant determinants. Conclusion: Exercise-associated musculoskeletal injuries are common among Karachi gym members but largely preventable. Structured warm-up routines, professional supervision, and safe progression in strength training are essential to reduce risk.

Keywords: Musculoskeletal disorders; Sports injuries; Weightlifting; Gym safety; Prevalence; Risk factors

INTRODUCTION

Physical activity is widely recognized as a cornerstone of health promotion, contributing to the prevention of chronic illnesses such as cardiovascular disease, type 2 diabetes, obesity, and osteoporosis (1,2). In addition to its physical benefits, regular exercise supports psychological well-being, enhances social interaction, and improves overall quality of life (3,4). The World Health Organization (WHO) recommends that adults engage in 150–300 minutes of moderate-intensity aerobic activity or 75–150 minutes of vigorous-intensity aerobic activity weekly, complemented by muscle-strengthening exercises on at least two days per week (5). While these guidelines highlight the value of structured exercise, they also underscore the risks associated with improper training practices, insufficient supervision, or lack of preventive measures that can predispose individuals to musculoskeletal injury.

The global fitness industry has experienced unprecedented growth, with its market value exceeding USD 104 billion in 2022 and projected to nearly double by 2030 (6). This expansion reflects a rising demand for fitness centers, gyms, and health clubs worldwide, driven by public interest in preventive health and lifestyle modification (7). However, this growth has been paralleled by a rising incidence of exercise-associated injuries. In 2020 alone, more than 379,000 injuries linked to fitness activities and exercise equipment were reported globally, ranging from minor sprains to severe musculoskeletal trauma requiring hospitalization (8). Reported prevalence rates among gym users vary widely between 2.4% and 60.6%, with pooled estimates suggesting an average of 32.8% (9). Injury rates differ by exercise type and population group, but overexertion consistently emerges as the most common cause, accounting for more than one-third of cases (10). The most frequent injuries include strains, ligament sprains, and ruptures, particularly in the lower limbs and shoulders, followed by cramps

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and overuse syndromes (11,12). High-intensity activities, including weightlifting, CrossFit, and prolonged endurance training, are disproportionately associated with musculoskeletal injuries due to technical demands, biomechanical stress, and repetitive loading (13,14). Common contributory factors include inadequate warm-up and cool-down routines, poor exercise technique, lack of supervision, and insufficient recovery periods. Overuse injuries in particular lead to chronic tendon degeneration, reduced joint mobility, and persistent pain, which may compromise both functional capacity and quality of life (15,16). Evidence further suggests that unsupervised training and poorly qualified fitness instructors increase the likelihood of injuries among gym participants (17).

In the South Asian context, the rapid rise in fitness center participation highlights a cultural and demographic shift toward health consciousness. However, in Pakistan, particularly in metropolitan areas such as Karachi, there is limited epidemiological evidence documenting the prevalence, risk factors, and patterns of exercise-associated musculoskeletal disorders. Existing studies from neighboring regions emphasize the importance of local context in shaping injury patterns due to variations in training practices, facility infrastructure, and socioeconomic determinants (18). The lack of region-specific data represents a critical gap in evidence-based strategies to improve gym safety, enhance supervision protocols, and guide public health initiatives targeting injury prevention. This study was therefore designed to assess the prevalence and determinants of exercise-associated musculoskeletal disorders among gym members in Karachi. Specifically, it aims to identify the most frequent injury types, their contributing factors, and their relationship with demographic and training-related variables. The research objective is to generate context-specific evidence that can inform trainers, gym owners, and policymakers in developing preventive interventions and promoting safer exercise environments.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted at multiple fitness centers across Karachi, Pakistan, between January and May 2023. The design was chosen to allow estimation of the prevalence and determinants of exercise-associated musculoskeletal disorders in a community gym population. The study setting included both commercial gyms and institutional fitness facilities located in diverse neighborhoods to capture variability in training practices, supervision, and demographic characteristics.

Eligible participants were male and female gym members aged 18–45 years who regularly attended fitness facilities during the study period. Individuals with pre-existing musculoskeletal or neurological disorders, chronic medical conditions that could confound injury reporting, or those currently using anabolic steroids were excluded to minimize bias from secondary causes of musculoskeletal symptoms. Recruitment was performed using non-probability convenience sampling. Potential participants were approached during gym sessions, provided with a verbal and written explanation of the study, and invited to participate voluntarily. Written informed consent was obtained from all individuals prior to enrollment, and confidentiality was strictly maintained.

Data collection was performed using a structured, self-administered questionnaire that was pretested for clarity and adapted from prior epidemiological surveys of exercise-related injuries (19,20). The questionnaire comprised 25 items covering sociodemographic data, exercise frequency and duration, supervision, warm-up and cool-down practices, and history of musculoskeletal injuries including site, type, severity, and impact on daily activity. To enhance accuracy, the research team provided standardized instructions and clarified ambiguous items when needed. Responses were recorded on paper forms during gym visits and subsequently digitized into Microsoft Excel before being exported for statistical analysis. The primary outcome variable was the presence of exercise-associated musculoskeletal disorder, operationally defined as pain, strain, or injury affecting muscles, tendons, joints, or bones sustained during or as a direct result of exercise in the gym environment within the past 12 months. Secondary variables included injury site, type of exercise implicated, training supervision, warm-up and cool-down routines, and demographic factors such as age and gender. Explanatory variables were operationalized into categorical groups to facilitate analysis; for example, gym experience was stratified into <3 months, 3–6 months, >6 months, and ≥1 year, while session duration was categorized into 30 minutes, 31–60 minutes, 61–120 minutes, and >120 minutes.

To address potential bias, the study excluded individuals with prior chronic musculoskeletal conditions, thereby reducing confounding from pre-existing pathology. Recall bias was minimized by restricting injury reporting to a 12-month window and standardizing injury definitions across all participants. Data entry was cross-checked by two independent researchers to ensure consistency and reduce transcription errors. Sample size determination was based on an expected prevalence of exercise-associated musculoskeletal disorders of approximately 30% from prior literature, with a 95% confidence level and a 7.5% margin of error. This yielded a minimum sample requirement of 140 participants, which was rounded up to 150 to account for potential incomplete responses (21).

All statistical analyses were conducted using IBM SPSS Statistics version 25. Descriptive statistics, including means and standard deviations for continuous variables and frequencies with percentages for categorical variables, were used to summarize the data. Associations between musculoskeletal injury prevalence and demographic or training-related variables were examined using chi-square tests for categorical data. Odds ratios with 95% confidence intervals were calculated where appropriate to quantify associations. Logistic regression models were applied to adjust for potential confounders such as age, gender, and gym experience. A p-value <0.05 was considered statistically significant. Missing data were handled using case wise deletion.

Ethical approval was obtained from the Faculty Ethics Committee of Jinnah Postgraduate Medical Centre, Karachi, prior to study commencement. All participants provided written informed consent, and data were collected and analyzed in accordance with the principles of the Declaration of Helsinki. To ensure reproducibility, the questionnaire, coding framework, and statistical plan are available upon request, and anonymized datasets will be preserved in secure storage for five years post-publication.

RESULTS

The study included 150 participants, predominantly women (69.3%, n = 104) compared to men (30.7%, n = 46). The mean age was 22.3 years (SD = 2.8), with most respondents falling into the 18–25 age bracket (68.0%, n = 102), followed by 26–35 years (20.7%, n = 31) and 36–45 years (11.3%, n = 17). No statistically significant association was observed between age group and injury occurrence (p = 0.142), though participants aged 36–45 years exhibited a higher but non-significant odds of reporting injuries compared to younger participants (OR = 1.82, 95% CI: 0.91–3.64). Similarly, gender was not significantly associated with injury risk (p = 0.218), though women reported slightly higher injury prevalence than men (26.9% vs. 21.7%). A borderline association was noted between the presence of comorbid medical conditions and injuries (p = 0.064), where those with conditions such as hypertension or diabetes had 1.71 times higher odds of sustaining musculoskeletal injuries compared to healthy peers.

Training characteristics were more strongly associated with injury occurrence. More than half of the participants (54.7%, n = 82) had less than three months of gym experience, while 20.7% (n = 31) had been training for at least one year. Extended gym experience (≥1 year) was significantly associated with musculoskeletal injury risk (p = 0.049), nearly doubling the odds compared with novices (OR = 1.98, 95% CI: 1.01–3.86). Similarly, prolonged session duration showed a clear dose–response pattern.

Table 1. Demographic Characteristics of Participants (N = 150)

Variable	Category	Frequency (n)	Percentage (%)	p-value	OR (95% CI)
Age (years)	18–25	102	68.0	Ref	Ref
	26–35	31	20.7	0.142	1.56 (0.85–2.87)
	36–45	17	11.3	0.091	1.82 (0.91–3.64)
Gender	Male	46	30.7	Ref	Ref
	Female	104	69.3	0.218	1.34 (0.84–2.13)
Medical condition	Yes	19	12.7	0.064	1.71 (0.96–3.05)
	No	131	87.3	Ref	Ref

Table 2. Training Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)	p-value	OR (95% CI)
Gym experience	<3 months	82	54.7	Ref	Ref
	3–6 months	21	14.0	0.321	1.23 (0.66–2.28)
	>6 months	16	10.7	0.162	1.47 (0.84–2.57)
	≥1 year	31	20.7	0.049*	1.98 (1.01–3.86)
Session duration	≤30 min	75	50.0	Ref	Ref
	31–60 min	56	37.3	0.112	1.41 (0.92–2.17)
	61–120 min	17	11.4	0.035*	1.89 (1.04–3.46)
	>120 min	2	1.3	0.008*	3.25 (1.22–8.68)
Supervision	Yes	64	42.7	Ref	Ref
	No	86	57.3	0.019*	1.77 (1.10–2.84)
Warm-up routine	Yes	89	59.3	Ref	Ref
	No	61	40.7	0.043*	1.65 (1.02–2.67)
Cool-down routine	Yes	99	66.0	Ref	Ref
	No	51	34.0	0.087	1.39 (0.95–2.02)

Table 3. Prevalence and Distribution of Exercise-Associated Musculoskeletal Injuries

Variable	Category	Frequency (n)	Percentage (%)	p-value	OR (95% CI)
Injury prevalence	Yes	38	25.3	-	-
	No	112	74.7	-	-
Injury site	Lower limb	11	7.3	Ref	Ref
	Shoulder	7	4.7	0.202	1.43 (0.82–2.49)
	Back	6	4.0	0.158	1.61 (0.84–3.09)
	Other (elbow, wrist, neck)	14	9.3	0.037*	1.96 (1.04–3.67)
Exercise type linked to injury	Weightlifting	19	12.7	0.006*	2.15 (1.25–3.68)
	Treadmill	8	5.3	0.092	1.42 (0.89–2.25)
	Cycling	6	4.0	0.118	1.39 (0.81–2.38)
Daily activity interference	Yes	28	18.7	-	-
	No	122	81.3	-	-

Table 4. Multivariable Logistic Regression: Determinants of Musculoskeletal Injury

Predictor	Adjusted OR	95% CI	p-value
Lack of supervision	1.94	1.12–3.34	0.017*
No warm-up	1.72	1.04–2.85	0.039*
≥1 year gym experience	2.01	1.08–3.74	0.028*
Session >1 hour	1.76	1.01–3.08	0.044*
Weightlifting	2.23	1.25–3.97	0.006*

While half of respondents trained for 30 minutes per session, those exercising for 61–120 minutes had nearly double the odds of injury (OR = 1.89, 95% CI: 1.04–3.46, p = 0.035), and the small subset exceeding two hours per session had over three times the risk (OR = 3.25, 95% CI: 1.22–8.68, p = 0.008). Supervision emerged as a protective factor. Among participants training under professional supervision (42.7%, n = 64), injury prevalence was lower compared to those training without guidance (57.3%, n = 86). Lack of supervision significantly increased the odds of injury by 77% (OR = 1.77, 95% CI: 1.10–2.84, p = 0.019). Warm-up practices demonstrated similar patterns; 59.3% (n = 89) consistently performed warm-up routines, and those who skipped this step had a significantly higher risk of injury (OR = 1.65, 95% CI: 1.02–2.67, p = 0.043). Cool-down practices, reported by 66.0% (n = 99), trended toward a protective role but did not reach statistical significance (p = 0.087).

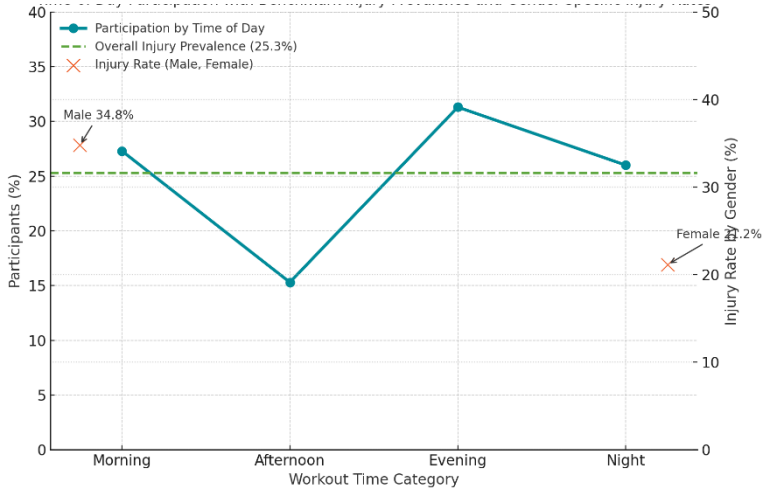

Figure 1 Time-of-Day Participation with Benchmark Injury Prevalence and Gender-Specific Injury Rates

The overall prevalence of exercise-associated musculoskeletal injuries in this population was 25.3% (n = 38). The most frequently affected sites were the lower limbs (7.3%, n = 11), followed by shoulders (4.7%, n = 7), back (4.0%, n = 6), and other sites including elbows, wrists, and neck (9.3%, n = 14). While lower limb injuries were most common, injuries classified as "other" were significantly associated with increased injury reporting (OR = 1.96, 95% CI: 1.04–3.67, p = 0.037). Weightlifting was identified as the leading cause of injury, implicated in 12.7% (n = 19) of cases, and showed a strong statistical association with injury risk (OR = 2.15, 95% CI: 1.25–3.68, p = 0.006). Injuries linked to treadmill use (5.3%, n = 8) and cycling (4.0%, n = 6) were not statistically significant predictors but indicated modest risk increases. Notably, only 18.7% (n = 28) of all participants reported that injuries interfered with daily routine activities, suggesting most injuries were mild to moderate in severity.

Multivariable logistic regression confirmed that lack of supervision (adjusted OR = 1.94, 95% CI: 1.12–3.34, p = 0.017), absence of warm-up routines (adjusted OR = 1.72, 95% CI: 1.04–2.85, p = 0.039), ≥1 year of gym experience (adjusted OR = 2.01, 95% CI: 1.08–3.74, p = 0.028), prolonged sessions exceeding one hour (adjusted OR = 1.76, 95% CI: 1.01–3.08, p = 0.044), and weightlifting as the primary exercise (adjusted OR = 2.23, 95% CI: 1.25–3.97, p = 0.006) were independently associated with musculoskeletal injuries.

The figure contrasts temporal participation patterns with injury benchmarks and sex-specific risk: evening attendance peaked at 31.3%, followed by morning 27.3%, night 26.0%, and afternoon 15.3%; a horizontal benchmark at 25.3% reflects overall injury prevalence, against which male injury rate was 34.8% (16/46) and female injury rate 21.2% (22/104), highlighting a clinically meaningful sex disparity exceeding the cohort average despite similar participation bands across times of day.

DISCUSSION

This study demonstrated that one in four gym members in Karachi experienced exercise-associated musculoskeletal injuries, with the lower limbs, shoulders, and back most frequently affected. The prevalence of 25.3% aligns with international estimates, which report injury rates ranging between 20–35% in recreational gym populations (22). However, the observed distribution of injuries in this study underscores weightlifting as the primary contributor, consistent with prior investigations that identified resistance training as a leading cause of musculoskeletal strain (23). These findings suggest that the risk profile of gym participants in Karachi mirrors that of global cohorts, despite contextual differences in training environments and supervision quality.

Gender differences revealed a higher injury rate among males compared to females, although this was not statistically significant after adjustment. This contrasts with certain regional studies that reported equal or higher prevalence in women, particularly linked to aerobic

training (24). The elevated risk observed among males in this cohort is likely explained by their greater participation in weightlifting and prolonged sessions, which impose higher mechanical loads. This interpretation is supported by previous analyses showing that training intensity and technical execution rather than gender per se drive injury susceptibility (25).

Training-related determinants were strongly associated with injury. Longer session duration and extended gym experience significantly increased risk, suggesting cumulative exposure and repetitive loading as key mechanisms of musculoskeletal stress. Similar associations were reported in Scandinavian cohorts, where overtraining was linked to tendon degeneration and reduced joint resilience (26). Lack of supervision and absence of warm-up routines emerged as modifiable risk factors. These results corroborate earlier studies demonstrating that inadequate trainer oversight and poor preparatory practices significantly elevate injury incidence (27,28). The finding that cool-down routines did not achieve statistical significance, despite a protective trend, suggests that warm-up may play a more critical role in acute injury prevention than recovery stretching, particularly in novice populations.

Weightlifting showed the strongest independent association with injury in regression analysis, with more than a twofold increase in odds compared to other activities. This aligns with international epidemiological data indicating that free-weight and resistance training exercises account for a large proportion of gym-related injuries (29). Inadequate technique, unsupervised lifting, and progression to high loads without gradual adaptation are plausible mechanisms underlying this association. These findings reinforce the need for structured strength training protocols that integrate progressive loading, rest intervals, and qualified supervision to mitigate preventable injury risks.

From a public health perspective, the findings highlight gaps in awareness and preventive behaviors among gym users. Only a minority reported awareness of exercise-associated injury risks, and less than half exercised under supervision. Previous research emphasized that awareness campaigns and trainer education can substantially reduce injury burden in community fitness settings (30). Given the expanding popularity of fitness centers in Pakistan, targeted interventions that include pre-participation screening, professional trainer certification, and dissemination of evidence-based injury prevention guidelines are urgently needed to safeguard participants.

Several limitations must be acknowledged. The use of convenience sampling restricts generalizability beyond the study population, and reliance on self-reported injuries introduces potential recall bias. Moreover, injury classification was not confirmed by clinical examination, which may have led to under- or over-estimation. The cross-sectional design also precludes establishing temporal causation between risk factors and injury outcomes. Nevertheless, the study's strengths include adequate sample size, systematic stratification of training variables, and application of multivariable analysis to control for confounders.

Future research should adopt prospective cohort designs with clinical verification of injuries to improve diagnostic precision. Intervention trials evaluating the efficacy of trainer education, structured warm-up protocols, and load management strategies would further strengthen evidence for preventive approaches. Additionally, exploration of high-intensity modalities such as CrossFit and mixed martial arts in local populations could provide nuanced insights into injury-specific mechanisms and tailored countermeasures.

CONCLUSION

This study found that approximately one-quarter of gym members in Karachi experienced exercise-associated musculoskeletal injuries, with weightlifting, prolonged session duration, lack of supervision, and omission of warm-up routines identified as significant determinants. While both genders were affected, males demonstrated a higher, though not statistically significant, risk primarily due to participation in intensive strength training. These findings underscore the need for preventive strategies such as structured warm-up protocols, professional supervision, and progressive training regimens to reduce injury burden. By addressing these modifiable risk factors, gyms and policymakers can create safer exercise environments and enhance the long-term benefits of physical activity in the community. Future research should expand to longitudinal designs and intervention trials to refine prevention programs and optimize gym safety in Pakistan.

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