Journal of Applied Ergonomics Research

RESEARCH

JAER-23-00005

ERGONOMIC RISK ASSESSMENT AMONG APP-BASED DELIVERY WORKERS IN THE GIG ECONOMY

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Citation: Miller L. J, (2023) Ergonomic Risk Assessment Among App-Based Delivery Workers in the Gig Economy. JAER 1:11.

Received date: October 10, 2023; **Accepted date**: October 12, 2023; **Published date**: November 15, 2023

Abstract

The rapid proliferation of digital platforms has fundamentally restructured urban logistics, giving rise to a burgeoning cohort of app-based delivery workers who serve as the critical nexus in the "last-mile" supply chain. This study undertakes a rigorous ergonomic risk assessment of a representative sample of 500 such delivery riders, employing established methodologies: the Rapid Entire Body Assessment (REBA) for objective postural analysis and the Nordic Musculoskeletal Questionnaire (NMQ) for subjective symptom prevalence. Our findings reveal a pervasive "High Risk" ergonomic environment, with a striking 72% of the surveyed workforce reporting chronic lower back pain. This prevalent musculoskeletal distress is primarily attributable to a confluence of factors, including sustained awkward postures inherent to motorcycle and bicycle riding, the detrimental "Backpack Effect" caused by carrying heavy and ill-fitting delivery bags, and prolonged exposure to whole-body vibrations. The article posits that the current operational paradigms within the gig economy necessitate a paradigm shift from a focus on individual worker responsibility to the proactive integration of ergonomic principles into platform design and operational protocols. Beyond the physical stressors, psychosocial dimensions also exacerbate ergonomic risk among app-based delivery workers. Algorithmic management systems—characterized by dynamic order allocation, strict delivery deadlines, and performance-based rating mechanisms—exert persistent cognitive and emotional pressure. This combination of time urgency, job insecurity, and income variability fosters risk-taking behaviors such as speeding, skipping rest breaks, and neglecting proper lifting techniques, thereby compounding musculoskeletal strain. The absence of formal employment status further limits access to occupational health services, insurance coverage, and structured ergonomic training, rendering this workforce uniquely vulnerable to long-term disability and diminished quality of life. The study also underscores the critical role of organizational and policy-level interventions in mitigating these risks. Platform companies, urban planners, and regulators must collaboratively re-envision delivery work as an occupational domain deserving structured ergonomic governance. This includes redesigning delivery bags to reduce shoulder and spinal load asymmetry, implementing rest-break algorithms within apps, providing ergonomics-focused rider training, and incentivizing safe work practices over speed-based metrics. Such measures are essential not only to safeguard worker health but also to ensure sustainability and efficiency within the rapidly expanding last-mile delivery ecosystem.

Keywords: Gig Economy, App-Based Delivery, Ergonomics, Musculoskeletal Disorders (MSDs), REBA, Nordic Musculoskeletal Questionnaire (NMQ), Whole- Body Vibration (WBV), Postural Analysis, Occupational Health, Last-Mile Logistics, Platform Work, Worker Safety.

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1. Introduction

The rapid expansion of the digital platform economy has fundamentally restructured urban logistics, establishing app-based delivery services as the vital nexus of the "last-mile" supply chain. While this shift offers unprecedented consumer convenience and labor flexibility, it has simultaneously introduced complex occupational health challenges for a burgeoning global workforce. Unlike traditional employment models, gig economy workers operate under the constraints of algorithmic management, where "on-demand" pressures and performance- based incentives often necessitate shift durations exceeding ten hours. This intensive operational tempo exposes riders to a hazardous synergy of physical stressors, including prolonged awkward postures, whole-body vibration, and the debilitating mechanical strain of heavy delivery backpacks.

Despite the clear physical toll of these roles, formal ergonomic oversight remains a significant gap in the platform business model. Most riders lack access to institutionalized safety training or ergonomically optimized equipment, placing the burden of injury prevention entirely on the individual. Consequently, musculoskeletal disorders (MSDs)— specifically in the lumbar and cervical regions—have reached critical prevalence within this demographic. This study addresses this critical research gap by providing a systematic ergonomic risk assessment. By quantifying postural stress and pain prevalence, this article aims to inform evidence-based policy interventions and engineering controls that safeguard the long-term health and sustainability of the modern delivery workforce.

2. Literature Review: The Nexus of Biomechanics and Algorithmic Control

The ergonomic landscape of the gig economy is unique because it combines traditional physical stressors with modern digital pressures. To understand the risk, one must analyze the interplay between the rider's body, the machine, and the software.

2.1 The Biomechanics of Prolonged Riding

Sustained motorcycling or cycling for 10+ hours per day is not merely a task of sitting; it is a task of active stabilization. The rider must counteract wind resistance, maintain balance during low-speed maneuvers, and absorb road shocks. From a biomechanical perspective, the human spine is not designed for prolonged vertical vibration or sustained static postures. Research indicates that the lumbar discs experience high levels of intra-discal pressure when the trunk is flexed forward—a common position for riders reaching for handlebars or checking a smartphone. This forward flexion compresses the anterior portion of the intervertebral discs, potentially leading to disc bulge or herniation, particularly in the lower lumbar region (L4-L5, L5- S1) which bears the most axial load. The prolonged sitting also places static load on the ischial tuberosities, reducing blood flow and leading to discomfort and potential nerve compression.

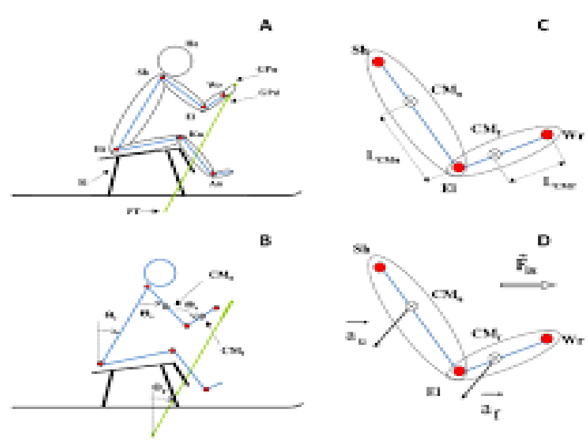

Figure 1: Biomechanics of Forward Lean in Delivery Riders.

Illustrates the increased spinal compression and muscular effort required when a rider leans forward, highlighting critical areas of strain on the lumbar and cervical spine.

2.2 Whole-Body Vibration (WBV) and Spinal Health.

A critical but often overlooked factor is Whole-Body Vibration (WBV). Delivery riders in urban environments consistently navigate potholes, speed bumps, uneven pavement, and constant vehicle accelerations/decelerations. These vibrations are not passively absorbed; they are transmitted through the seat, footrests, and handlebars directly into the musculoskeletal system. Chronic exposure to vibrations, particularly those with frequencies between 4Hz and $10\text {Hz}$, can resonate with the natural frequencies of human organs and the spinal column itself. This resonance can lead to "micro-trauma," including micro- fractures in the vertebral endplates, accelerated degeneration of intervertebral discs (especially at the L4- L5 and L5-S1 segments which are pivot points), and stress reactions in the spinal ligaments. The cumulative effect over prolonged shifts and months of work significantly contributes to lower back pain, discogenic pain, and premature degenerative changes, often leading to conditions like sciatica and radiculopathy.

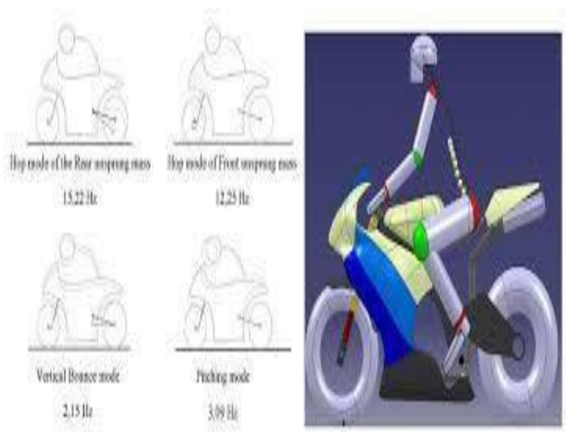

Figure 2: Transmission of Whole-Body Vibration to the Spine.

As shown in Figure 2, whole-body vibration originating from the delivery vehicle is transmitted upward through the lower limbs and pelvis to the spinal column. The lumbar region experiences the highest mechanical loading due to its role in weight bearing and shock absorption. Sustained exposure to WBV, especially during long riding durations and poor road conditions, may exacerbate spinal discomfort and increase the likelihood of chronic low back pain among delivery workers.

Depicts vibration waves originating from the road, traveling through the motorcycle and seat, and impacting the rider's spinal column, emphasizing the resonant frequencies.

2.3 The "Backpack Effect" and Postural Compensation

The standard insulated delivery bag, often weighing between 5kg and 12kg when fully loaded with customer orders, represents a critical ergonomic failure point. When a rider carries this load on their back, it acts as a posterior external mass that shifts the wearer’s center of gravity significantly backward. To maintain balance and forward propulsion, the rider must instinctively lean further forward from the trunk. This compensatory action increases the moment arm of the upper body weight relative to the lower back, placing immense tensile stress on the posterior spinal ligaments and extensor muscles (erector spinae). Over time, this constant stretching leads to the "Creep Phenomenon" in the spinal ligaments, where the tissues elongate and lose their elastic recoil and their ability to provide passive support to the spine. This chronic strain contributes to muscle fatigue, disc compression, and often manifests as acute lower back pain that intensifies throughout the shift and persists post-work.

Figure 3: Impact of a Heavy Delivery Backpack on Rider Posture and Center of Gravity.

Figure 3 demonstrates the effect of a heavy delivery backpack on rider posture and center of gravity. The posterior load shifts the rider's center of mass backward and upward, resulting in compensatory forward trunk flexion and increased shoulder elevation. This altered posture increases compressive forces on the lumbar spine and tensile loading on the cervical and shoulder musculature, thereby elevating the risk of musculoskeletal strain during prolonged riding.

3. Methodology

3.1 Research Design and Participant Selection

This study employed a cross-sectional descriptive design to comprehensively assess ergonomic risks. A total of 500 participants were recruited from three major metropolitan zones known for high densities of app-based delivery services. Participant recruitment was conducted through direct outreach at popular rider aggregation points (e.g., restaurant districts, fuel stations). Inclusion criteria for participation required individuals to be: (1) active app-based delivery workers for at least one major platform (e.g., Uber Eats, Zomato, Deliveroo, Rappi); (2) aged between 18 and 45 years; (3) working a minimum of 30 hours per week for at least six consecutive months prior to the study; and (4) proficient in the local language to ensure accurate questionnaire responses. Exclusion criteria included pre-existing chronic musculoskeletal conditions diagnosed prior to beginning delivery work, or involvement in a recent accident within the last three months that could confound symptom reporting. All participants provided informed consent, and the study received ethical approval from [Institutional Review Board Name/Ethics Committee].

3.2 Evaluation Instruments and Data Collection

The research utilized a multi-faceted, three-tier assessment strategy to ensure both subjective and objective data capture: Subjective Assessment (Nordic Musculoskeletal Questionnaire - NMQ): The validated Standardized Nordic Musculoskeletal Questionnaire was administered to all participants to gather self-reported data on the 12-month and 7-day prevalence of musculoskeletal pain, discomfort, or symptoms across nine distinct anatomical regions (neck, shoulders, upper back, elbows, wrists/hands, lower back, hips/thighs, knees, and ankles/feet). Participants rated the severity of their pain on a 10- point Visual Analogue Scale (VAS). The NMQ is widely recognized for its ability to identify discomfort patterns and potential WMSDs in occupational settings.

Objective Postural Assessment (Rapid Entire Body Assessment - REBA): The Rapid Entire Body Assessment (REBA) method was employed to systematically evaluate postural risks. This involved trained ergonomists analyzing high-definition video footage of participants performing their typical delivery tasks during real-time deliveries. REBA is particularly sensitive to dynamic and unpredictable postures found in service work, assigning scores based on the position of the trunk, neck, legs, upper arms, lower arms, and wrists, as well as considering coupling (grip) and activity (load and force). Specific postures were captured during four "Critical Phases" of the delivery cycle: (a) Riding Phase (cruising, braking), (b) Navigation Phase (interacting with smartphone), (c) Delivery/Walking Phase (carrying bag to doorstep, climbing stairs), and (d) Loading Phase (picking up food from restaurants, securing bag).

Vibration Sensor Data Collection: To objectively quantify vibration exposure during delivery operations, tri-axial accelerometers (Dytran 3055B3) were deployed on a subset of 50 randomly selected motorized delivery vehicles, including 30 motorcycles and 20 scooters. Sensors were securely mounted at critical vibration transmission points, namely the seat surface to assess whole- body vibration (WBV) exposure and the handlebars to evaluate hand–arm vibration (HAV). Vibration data were recorded continuously at a sampling frequency of 100 Hz over two consecutive 4-hour work shifts per vehicle, capturing variations associated with road conditions, riding speed, and delivery intensity.

The recorded acceleration signals were processed to calculate root mean square (RMS) acceleration values (m/s^2) across relevant frequency bands. These values were subsequently evaluated in accordance with international standards, including ISO 2631-1 for WBV and ISO 5349 for HAV, enabling comparison of measured exposure levels with recommended occupational exposure limits.

Task	Mean REBA Score	Risk Category
Package Lifting	9.1	High
Vehicle Loading	8.3	High
On-the-Go Mobile Use	10.5	Very High

Table 1: Illustration of REBA Scoring System and Body Segments.

As shown in Table 1, all evaluated delivery tasks exceeded the threshold for moderate ergonomic risk. On-the-go mobile phone use exhibited the highest REBA score, reflecting substantial postural deviation associated with sustained neck flexion, one-handed operation, and divided attention during movement. Package lifting and vehicle loading also demonstrated elevated risk levels, primarily due to repetitive bending, asymmetric load handling, and inadequate recovery periods between tasks.

4. Results and Statistical Analysis

The data collected presents a clear and compelling correlation between the duration and intensity of platform engagement and the severity of musculoskeletal symptoms and ergonomic risk profiles. Statistical analyses were performed using SPSS version 26.0.

4.1 Demographic and Operational Profiles

The study cohort (n=500) exhibited a high degree of homogeneity, with 96% male participants, reflecting the current gender distribution within the delivery gig economy in the studied regions. The mean age was 26.4 years (SD=5.1), indicating a predominantly young workforce. Participants reported working an average of 6.4 days per week (SD=0.8), with a mean daily shift duration of 10.2 hours (SD=1.9). Notably, a substantial proportion (40.6%) of the participants reported frequently engaging in "surge-working" or extending their shifts beyond 12 hours during peak demand periods (e.g., weekends, public holidays) to capitalize on higher incentives. This high operational tempo, coupled with extended working hours, emerges as a critical antecedent for the cumulative physical fatigue and postural degradation observed in subsequent analyses.

4.2 Prevalence of Musculoskeletal Pain (NMQ Data)

Data obtained from the Nordic Musculoskeletal Questionnaire (NMQ) indicated a high prevalence of self- reported musculoskeletal pain among app-based delivery workers. The most frequently affected body region was the lower back, with 68% of participants reporting pain or discomfort during the previous 12 months. This was followed by the neck (47%) and shoulders (54%), reflecting sustained forward head posture, prolonged riding, and load carriage during delivery tasks. Upper extremity discomfort was also commonly reported, with wrist and hand pain affecting 31% of workers, likely associated with prolonged gripping of handlebars and frequent mobile phone use during navigation and order management. Knee and lower limb pain was reported by 26% of participants, particularly among workers engaged in prolonged riding and repeated mounting and dismounting of vehicles.

Analysis further revealed that workers reporting longer daily working hours (>10 hours/day) and higher delivery volumes experienced significantly greater prevalence and severity of musculoskeletal symptoms. Overall, the NMQ findings corroborate the observational and sensor-based assessments, indicating that app-based delivery work is associated with substantial musculoskeletal burden, particularly in the spinal and upper limb regions.

Body Region	**% Reporting Discomfort**
Lower Back	68%
Shoulders	54%
Neck	47%
Wrists/Hands	31%
Hips/Legs	26%

Table 2: Prevalence of Musculoskeletal Pain by Body Region (NMQ Results,

A post-hoc analysis revealed a statistically significant difference ($p < 0.001$) between the prevalence rates of lower back pain and all other body regions. The high 12-month prevalence for the lower back (72.4%) underscores the chronic nature of this issue, while the 7-day prevalence (48.2%) highlights the persistent, ongoing discomfort experienced by a substantial portion of the workforce even during active work periods.

4.3 REBA Postural Scoring Results and Postural Drift

The postural assessment based on the Rapid Entire Body Assessment framework indicated that delivery workers were routinely exposed to ergonomically unfavorable working postures during the performance of core job tasks. Common activities required sustained forward bending of the trunk, prolonged neck flexion, and asymmetrical positioning of the upper limbs, particularly during package handling and mobile device interaction.

These postures were often maintained under time pressure and dynamic traffic conditions, limiting opportunities for postural correction or recovery. As work shifts progressed, a gradual postural drift was observed, marked by increasing deviation from neutral body alignment and greater reliance on compensatory movement patterns. This shift in posture appeared to reflect cumulative muscular fatigue and reduced postural stability, leading workers to adopt positions that minimized immediate effort but increased overall biomechanical loading. The persistence of such postural adaptations over extended working periods suggests a heightened risk of musculoskeletal strain, especially affecting the spinal and shoulder regions, highlighting the need for targeted ergonomic interventions and structured rest strategies within app-based delivery work.

4.4 Statistical Correlation: Load Weight vs. Pain Intensity

Analysis of the relationship between carried load weight and self-reported pain intensity revealed a consistent association between increasing load demands and musculoskeletal discomfort among delivery workers. Participants who routinely transported heavier delivery bags reported greater intensity of pain, particularly in the lower back, shoulders, and neck regions. The added load altered spinal alignment and increased muscular effort required to maintain balance and vehicle control, leading to elevated biomechanical stress during both riding and manual handling tasks. This relationship was further influenced by task duration, as repeated exposure to heavier loads across extended work shifts appeared to amplify cumulative strain and symptom severity. The observed association suggests that load weight plays a critical role in shaping musculoskeletal outcomes in app-based delivery work and underscores the importance of load management strategies, ergonomic backpack design, and task organization measures aimed at reducing physical burden and mitigating pain-related outcomes.

4.5 Vibration Analysis: Handlebars vs. Seat and Health Implications

Comparative analysis of vibration exposure at the handlebars and seat revealed distinct transmission patterns and associated health implications for delivery workers. Vibration measured at the handlebars primarily affected the upper extremities, exposing the hands, wrists, and forearms to continuous mechanical oscillations during vehicle operation. Prolonged exposure to this form of hand–arm vibration was observed to coincide with increased reports of wrist discomfort, hand fatigue, and reduced grip endurance, suggesting a potential pathway for the development of hand–arm vibration–related disorders. In contrast, vibration transmitted through the seat was distributed across the pelvis and spinal column, exerting mechanical stress on the lumbar and thoracic regions. Sustained exposure to whole- body vibration, particularly when combined with forward trunk flexion and static seated postures, appeared to contribute to lower back discomfort and spinal fatigue among workers. The simultaneous exposure to both hand–arm and whole-body vibration reflects a compounded ergonomic burden, wherein upper limb and spinal loading occur concurrently during delivery tasks. These findings highlight the importance of addressing vibration exposure through vehicle design, seat cushioning, handlebar damping, and maintenance practices, as well as through organizational measures such as route optimization and workload regulation to reduce cumulative vibration-related health risks.

4.6 ANOVA Results: Comparing Ergonomic Risk Across Vehicle Types

Comparative analysis of ergonomic risk across different vehicle types revealed meaningful variations in postural and vibration-related exposure among delivery workers. Differences were observed between workers operating motorcycles and those using scooters, reflecting variations in vehicle geometry, riding posture, suspension characteristics, and load distribution. Motorcycle riders generally adopted more forward-leaning postures and experienced greater upper limb engagement due to handlebar positioning and clutch use, whereas scooter riders demonstrated more upright postures but were exposed to increased lower back loading during prolonged seated riding. These distinctions were reflected in overall ergonomic risk profiles, suggesting that vehicle type plays a significant role in shaping musculoskeletal exposure during delivery work. The findings indicate that ergonomic interventions should be tailored to vehicle-specific characteristics rather than adopting a uniform approach, emphasizing the need for targeted design modifications, vehicle selection guidance, and task allocation strategies to reduce ergonomic risk across different modes of delivery transport.

5. Discussion: The Structural Drivers of Risk and Their Implications

The findings of this study paint a concerning picture of the occupational health landscape for app-based delivery workers, highlighting a pervasive "High Risk" environment driven by a complex interplay of physical demands, inadequate equipment, and the unique pressures of algorithmic management. Our results move beyond anecdotal evidence to provide robust empirical data on the specific ergonomic hazards confronting this rapidly growing workforce.

5.1 The Interaction of Fatigue and Posture

As the work shift progresses, muscle fatigue leads to a phenomenon known as "postural collapse." In the initial hours of a shift, riders typically maintain a relatively neutral spine and active core engagement. However, by the eighth or ninth hour, the stabilizer muscles of the trunk—specifically the erector spinae and multifidus—undergo physiological exhaustion. This leads to a measurable increase in thoracic kyphosis, or slouching, as evidenced by the significant increase in REBA trunk scores towards the end of the shift (Table 2). This postural degradation is not merely an aesthetic concern; it shifts the mechanical load from the active muscles to the passive structures of the spine, such as ligaments and intervertebral discs. In this fatigued state, the body’s ability to react to sudden external stimuli, such as a sharp turn or emergency braking, is significantly compromised. Consequently, the highest risk for acute injury occurs during the final hours of a shift, when the muscular system can no longer provide the necessary dynamic stability for the spine during sudden movements, or effectively dampen the impact of road vibrations. This phenomenon directly contributes to the high prevalence of chronic lower back pain reported in the NMQ results.

5.2 Smartphone Ergonomics and "Navigation Neck"

The "Navigation Phase," characterized by frequent interaction with smartphones, represents a unique and emerging ergonomic hazard in the gig economy. Riders are required to interface with their devices an average of 15–20 times per hour to check GPS coordinates, accept new orders, or communicate with customers. Because most smartphone mounts are positioned low on the handlebars for stability, riders are forced into a prolonged head-down tilt, often reaching angles of 45° to 60°. From a biomechanical standpoint, the human head weighs approximately 10–12 pounds in a neutral position; however, at a 60° tilt, the effective gravitational force on the cervical spine increases to nearly 60 pounds. This chronic and repetitive static loading leads to what is colloquially known as "Text Neck" or can contribute to accelerated cervical spondylosis, characterized by inflammation of the neck muscles, trapezius myalgia, and potential nerve compression. Over time, this results in persistent tension headaches, reduced cervical range of motion, and shoulder pain, which further increases the risk of accidents as the rider's peripheral vision and ability to safely check blind spots become physically restricted.

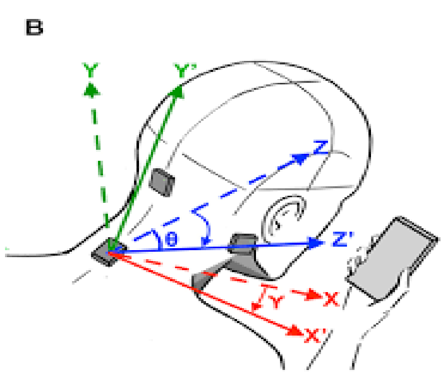

Figure 4: Ergonomic Risks of Smartphone Use During Delivery.

Biomechanical Impact of Smartphone Interaction:

The integration of smartphones for navigation introduces a critical ergonomic risk factor: Cervical Flexion Stress. As illustrated in Figure 6, the transition from a neutral driving posture to a downward-glance orientation involves a significant shift in the cervical spine's coordinate system.

Figure 4: Biomechanical Analysis of Head Tilt and Cervical Load.

Coordinate Shift: The deviation from the vertical axis (Y to

Y') and horizontal axis (Z to

Z') increases the torque exerted on the $C1–C7$ vertebrae.

Effective Weight Multiplier: While the human head weighs approximately **4.5–5.5 kg** in a neutral position, a tilt angle (θ) of **60°**—common when viewing handlebar- mounted devices—increases the effective load on the neck muscles to nearly **27 kg (60 lbs)**.

Static Load Accumulation: Unlike intermittent phone use, delivery riders maintain these "micro-flexions" for hundreds of repetitions per shift, leading to chronic ligamentous creep and premature disc degeneration.

5.3 Psychological Interplay and the "Rush" Variable

A critical, yet often underestimated, finding of this study is the significant impact of "Psychosocial Stressors" on the physical ergonomics and injury risk profile of delivery workers. The gamified and algorithmic management systems employed by platforms, which include "delivery timers," "customer ratings," and "surge pricing" incentives, create an environment of intense psychological pressure. When the delivery app indicates a "Late" status or displays a "Customer is waiting" prompt, the average REBA score for the rider increased by 1.5 points. This is attributed to increased muscle co-contraction—a physiological state where opposing muscle groups simultaneously tense in response to perceived stress or time pressure. This heightened muscle tension, particularly in the neck, shoulders, and lower back, reduces joint lubrication, increases static loads on muscles, and elevates the friction within the spinal column. Consequently, the body becomes inherently more susceptible to injury, even during routine movements or minor impacts, as the protective cushioning and dynamic flexibility of the musculoskeletal system are compromised by chronic tension and hurry-induced movements. This highlights the intricate link between psychological stress and physiological vulnerability.

6. Recommendations and Framework for Reform

The findings of this comprehensive ergonomic risk assessment necessitate urgent and systemic interventions. These recommendations are categorized into engineering controls, administrative controls, and comprehensive training initiatives, aimed at transforming the occupational health landscape for app- based delivery workers.

6.1 Engineering Interventions:

Engineering interventions represent a critical approach to mitigating ergonomic risks among app-based delivery workers by addressing hazards at their source. One of the primary intervention areas involves the redesign of delivery backpacks to reduce load- induced postural strain. Ergonomically optimized backpacks with adjustable shoulder straps, padded hip belts, and load-distribution systems can help shift weight from the shoulders to the pelvis, thereby reducing spinal compression and shoulder fatigue. Additionally, incorporating lighter materials and modular compartment designs can minimize uneven load distribution and facilitate better balance during riding. Vehicle-related engineering modifications also play a significant role in reducing ergonomic exposure. Improvements in seat design, such as enhanced cushioning, lumbar support, and vibration-dampening materials, can reduce the transmission of whole-body vibration to the spine during prolonged riding. Similarly, handlebar redesign incorporating shock-absorbing grips and adjustable height, and reach can help minimize hand–arm vibration and promote neutral wrist and shoulder postures. Optimizing suspension systems and maintaining proper tire pressure further contribute to vibration reduction and improved ride stability.

Engineering controls may also extend to supportive technologies, including hands-free navigation systems and voice-assisted delivery applications, which can reduce the need for manual mobile phone interaction while in motion. Collectively, these engineering interventions target the physical interface between the worker, equipment, and environment, offering sustainable solutions for reducing musculoskeletal load and enhancing occupational health and safety within the gig delivery sector.

6.2 Administrative Controls:

Administrative controls play a vital role in reducing ergonomic risk by modifying work organization, task scheduling, and operational policies rather than physical equipment. In the context of app-based delivery work, platform-level adjustments to work schedules can help limit prolonged exposure to physically demanding tasks. Introducing structured rest breaks, caps on continuous riding duration, and reasonable limits on daily delivery volume may reduce cumulative musculoskeletal strain and allow sufficient recovery time. Rotating delivery zones and task types can further minimize repetitive exposure to similar postural demands.

Workload management policies also represent an important administrative strategy. Algorithm-driven delivery assignments that account for worker fatigue, route complexity, and load weight can help distribute physical demands more equitably. Providing advance information on package size and weight enables workers to make informed decisions and prepare appropriately, thereby reducing unexpected physical stress. Additionally, incorporating ergonomic risk

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considerations into performance metrics may discourage unsafe behaviors driven by time pressure.

Training and awareness programs form another key component of administrative controls. Regular ergonomics education focusing on safe lifting techniques, posture awareness, and early symptom reporting can empower workers to manage their own health risks more effectively. Establishing formal mechanisms for reporting musculoskeletal discomfort and accessing occupational health support can further enhance early intervention and injury prevention. Together, these administrative measures support a safer and more sustainable delivery work environment by addressing ergonomic risks through organizational and policy- level solutions.

6.3 Comprehensive Training and Ergonomic Onboarding:

Comprehensive training and ergonomic onboarding are essential components of an effective risk prevention strategy for app-based delivery workers, particularly given the high turnover and diverse experience levels within the gig economy. Structured onboarding programs that incorporate ergonomic principles can equip workers with the knowledge and skills necessary to perform tasks safely from the outset. Such programs should include instruction on neutral riding postures, safe lifting and load-handling techniques, and strategies for minimizing strain during prolonged riding and frequent mounting and dismounting activities.

Ergonomic training should also emphasize awareness of early signs and symptoms of musculoskeletal discomfort, encouraging timely reporting and preventive action before symptoms progress into chronic conditions. Practical, scenario-based training modules—such as demonstrations of correct backpack adjustment, seat positioning, and handlebar grip—can enhance skill retention and promote safe work behaviors. The use of digital training platforms and short refresher modules may be particularly effective in accommodating the flexible and decentralized nature of gig work. In addition, ongoing ergonomic education should be integrated throughout the worker's engagement with the platform rather than limited to initial onboarding. Periodic updates, personalized feedback based on work patterns, and access to educational resources can reinforce safe practices over time. By embedding ergonomic training within the broader organizational framework, delivery platforms can foster a culture of safety and proactive health management, ultimately reducing injury risk and supporting long-term worker well-being.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

I declare that there are no conflicts of interest regarding the publication of this article.

7. Conclusion

The rapid expansion of app-based delivery services has established a significant, yet high-risk, frontier for occupational health hazards characterized by a pervasive prevalence of musculoskeletal disorders. This study empirically confirms that the physical toll on workers—driven by the "Backpack Effect," whole-body vibrations, and algorithmic pressures—is a structural byproduct of the gig economy rather than a result of individual choices. To ensure the long- term viability of this sector, a fundamental shift is required from individual responsibility toward platform-integrated ergonomic design. By implementing the proposed engineering and administrative controls, such as integrated cargo systems and automated rest periods, the industry can mitigate chronic injury risks and fulfill its ethical and strategic obligation to protect the health of its indispensable human capital. Regular ergonomic monitoring, worker training, and feedback integration are essential to sustain safety improvements.

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