Effectiveness and Usability of a Trunk Posture Feedback System: A Longitudinal Field Study for up to Six Weeks in a Distribution Center

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Conflict of Interest

The authors declare no conflict of interest.

ABSTRACT

Postural feedback systems are a potential ergonomic intervention to reduce postural exposures and mitigate musculoskeletal disorder risk, yet field-based evidence on their long-term effectiveness remains limited. We investigated a commercially available postural feedback system implemented in a logistics environment, which provided auditory and vibrotactile feedback in response to excessive trunk flexion. Thirty-two workers used the system for up to six weeks. No initial improvements in postural exposures were observed between baseline (Day 1, no feedback) and the first few days of feedback (Days 2–4). Mixed-effects models indicated no sustained improvements over time, with substantial variability across participants. Participants reported that the system was easy to use and increased postural awareness, although some noted inconsistencies in feedback. These findings suggest that more precise and context-aware feedback systems might better promote sustained behavioral change, though our results should be interpreted in the context of the specific system and work environment evaluated.

Keywords: Posture assessment; Real-time feedback system; Wearable sensor; Musculoskeletal disorders; Field investigation

1. INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are a major health concern in the logistics industry (Chen et al., 2023; BLS, 2023a). In the U.S. in 2023, workers in the transportation and warehousing sector experienced 4.5 recordable injuries or illnesses per 100 full-time workers, nearly twice the rate reported for all private industries (BLS, 2023b). About 40% of logistics workers in vehicle manufacturing enterprises reported experiencing WMSDs, with approximately one-quarter of all reported symptoms affecting the low back (Chen et al., 2023; Gomes et al., 2023). Manual material handling tasks common in logistics expose workers to major risk factors of low back pain (LBP) such as non-neutral postures and repetitive movements (e.g., Garg et al., 2014; Hoy et al., 2014; McGill, 2015). Consequently, mitigating these risk factors is a priority in this sector.

Administrative interventions, such as educating workers on safe lifting techniques, generally have shown limited effectiveness in reducing LBP (Denis et al., 2020). This limited effectiveness is often attributed to the difficulty of translating theoretical knowledge into practice during demanding physical work (Demoulin et al., 2012; Hogan et al., 2014). Consistent with this challenge, studies of behaviorally oriented lifting training have similarly shown that simply attending training does not guarantee safer long-term behaviors; instead, lasting improvement requires that workers achieve a sufficient level of proficiency (Lavender et al., 2007). To address this disconnect between knowledge and action, real-time postural feedback systems have emerged as a more promising alternative for reducing biomechanical exposures (e.g., Lee et al., 2021; Lind, 2024b). Typically, these systems use wearable sensors (e.g., an inertial measurement unit or IMU) together with algorithms that detect high-risk trunk movements, triggering immediate visual, auditory, and/or vibrotactile feedback to promote postural correction and awareness (Lim and Yang., 2023; Lind et al., 2023a; Kent et al., 2023; Au et al., 2025; Choi et al., 2025).

Recent reviews have noted that, while many laboratory-based studies have demonstrated that postural feedback can elicit immediate postural improvements, evidence from real-world settings is less clear (Frasie et al., 2023; Lind, 2024a; 2024b). A critical limitation of prior field studies is their short feedback engagement time, which often ranges from a few minutes to less than an hour (e.g., see Table 1 in Choi et al., 2025). Such brief engagements make it difficult to determine if initial improvements are due to genuine behavioral change or a temporary “novelty effect.” For example, our recent exploratory study (Choi et al. 2025; *n*=7), using a commercially available IMU-based system in a vehicle manufacturing environment, indicated that initial reductions in hazardous trunk flexion were not sustained over a 10-day period. Therefore, larger and longer-term field evaluations are needed to determine if these systems can foster lasting postural change.

The goal of our study was to evaluate the longer-term effectiveness and usability of a commercially available postural feedback system in a logistics environment, specifically an auto-parts distribution center. Over a 6-week period, we tracked postural exposure and subjective feedback from distribution center workers using the system during their regular work shifts. Our first hypothesis was that using the postural feedback system would lead to initial improvements in postural exposures when feedback was first introduced. This hypothesis was based on prior studies showing initial improvements in postural exposures upon introducing augmented feedback (Lind et al., 2024a; 2024b). Our second hypothesis was that using the postural feedback system would result in sustained or consistent reductions in postural exposures over time. This hypothesis was based on the inclusion of extended feedback engagement across full work shifts, which may provide increased opportunities for repeated correction and learning, potentially supporting longer-term behavioral adaptation (Adams, 1971, Schmidt, 1975).

2. METHODS

2.1. Participants

Potential participants were recruited from two daily shifts (receiving and shipping) at an auto-parts distribution center. Both shifts included three job titles: 1) small parts operators using manual carts for parts delivery (MCOs), 2) large parts operators using forklifts for parts delivery (FLOs), and 3) large parts operators using gofers (riding pallet jacks) for parts delivery (GFOs). All three job titles involved manual material handling tasks, including picking, positioning, loading, and handling items before and after transport, which required repetitive trunk flexion. Thirty-two material handlers (23 males and 9 females) with consistent 8-hour daily shifts (5 days/week) volunteered to participate. Of these participants, 19 were MCO workers, seven were FLO workers, and six were GFO workers. Since our main interest was in longer-term effects of feedback, participants who used the system for less than five days were excluded from our analysis (reasons for early dropout are described in the Discussion). Doing so resulted in a final sample of 20 participants (15 males and 5 females), including nine MCO workers, six FLO workers, and five GFO workers. For this final sample, respective means (SDs) of age and seniority were 38.4 (10.8) years and 8.6 (7.8) years. Detailed participant characteristics are provided in Appendix A. Prior to any data collection, participants were fully informed of the experimental protocols, and the study procedures were approved by GM Health and Safety and the Virginia Tech Institutional Review Board (IRB 23–1253).

2.2. Postural feedback system

Participants used the SoterCoach postural feedback system (Soter Analytics, Wilmington, DE, USA). Relevant hardware, data processing, and outcome measures have been detailed previously (Choi et al., 2025), so only a brief overview is provided here. The system includes a wearable sensor, with an IMU that monitors trunk flexion, lateral bending, and axial rotation. The sensor system is designed to deliver real-time auditory and vibrotactile feedback when hazardous trunk postures are detected over the course of complete work shifts. A proprietary algorithm determines trunk flexion relative to a user’s upright reference posture. A threshold-based sampling method records data only during “events,” defined as instances when trunk flexion exceeds 30˚. All recorded data are stored on the device and uploaded to a cloud server at the end of a work shift. For each event, the system stores key outcome measures, including the event duration and the peak and mean angles of trunk flexion and axial rotation. Feedback is triggered only when an event is classified as a postural “hazard.” Hazardous postures are defined by manufacturer-provided thresholds: excessive flexion (trunk flexion angle > 85˚), excessive axial rotation (trunk axial rotation angle >35˚ combined with flexion angle >50˚), or high-intensity flexion identified by the proprietary algorithm. Each hazard type triggered distinct auditory and vibrotactile feedback. As noted in our earlier report (Choi et al., 2025), we focused on hazardous trunk flexion because our preliminary system testing suggested more consistent detection of sagittal-plane flexion compared with other types of motion, including axial rotation. This approach was further supported by extant evidence indicating that IMU-based rotation measurements may demonstrate comparatively lower validity than sagittal-plane flexion (Poitras et al., 2019). The feedback for hazardous flexion consisted of a 0.5-second of vibration paired with an auditory beep. The warehouse environment was not excessively loud, and hearing protection was not used by workers during the study period.

2.3. Experimental design and procedures

A longitudinal study design was used to assess the effectiveness of the postural feedback system over a 6-week (30-workday) period (Fig. 1). Prior to deployment, all participants attended an orientation session during which they learned about the purpose of the study, were trained on how to don/doff the sensor, how to adjust the intensity of feedback, and were asked to familiarize themselves with the feedback criteria for each hazardous motion. Participants were instructed to collect a sensor from a charging/docking hub at the start of their shift, attach it to the back of their shirt collar, and return it to the hub at the end of their shift. Following the manufacturer's recommendation, Day 1 served as a no-feedback baseline period to capture typical (reference) postural behavior. For the remainder of the study, the system's auditory and vibrotactile feedback was enabled.

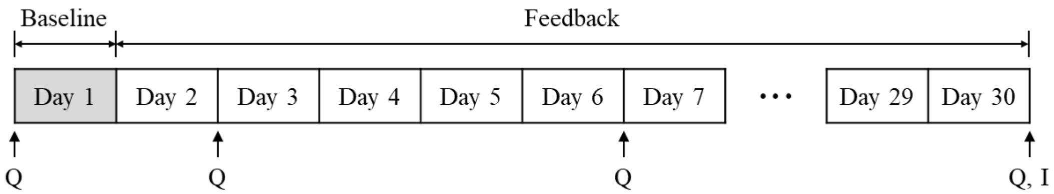

Fig. 1. Timeline of postural feedback system use and data collection milestones. Feedback was not provided on Day 1 to establish baseline measurements. Note: "Q" indicates when a questionnaire was completed, and "I" indicates the exit interview.

Four daily objective measures were derived from sensor data, based on the frequency and peak flexion angles for both events and hazards:

1. Frequency of events (F_{events}): the number of events divided by the total working hours
2. Frequency of hazards ($F_{hazards}$): the number of hazards divided by the total working hours
3. Peak angle during events (A_{events}): the mean of peak angles across all events
4. Peak angle during hazards ($A_{hazards}$): the mean of peak angles across all hazards

To ensure data quality, we removed the first and last 20 events recorded each day, which helped reduce artifacts associated with sensor setup, removal, or transitions into and out of work activities. This threshold was determined based on an initial inspection of the data and resulted in the removal of 6.6% of the total events recorded per participant per day. Events with peak trunk flexion angles greater than 150° were also excluded, as these values typically reflected sensor displacement or non-work movements. In addition, we removed data from entire days when the sensor signals showed clearly invalid patterns, such as unrealistically large axial rotation angles or other inconsistencies indicating that the device was not worn properly. After these exclusions, the mean (SD) number of workdays with valid sensor data across participants was 17.5 (6.2), and by job was 16.2 (7.8) for MCO workers, 17.2 (4.5) for FLO workers, and 20.2 (4.9) for GFO workers.

Subjective outcome measures were collected via questionnaires and exit interviews (see Fig. 1 for timing). Participants completed a self-administered baseline questionnaire (including questions about demographics and job information) and follow-up questionnaires on Days 2, 6, and 30 at the end of the respective work shift. Note that these days were used even for participants that ended sensor use prior to Day 30. The questionnaire on Day 30 included items regarding usability and general impressions of the feedback system (e.g., most or least liked aspects). The usability questionnaire was adapted from Choi et al. (2025), specifically by refining question wording for clarity and removing negatively phrased items. The final questionnaire addressed topics such as ease of use, comfort, interference, recommendation, consistency, clarity, and privacy using 7-point Likert scales. Within a few days of completing Day 30, we conducted semi-structured exit interviews to gather participants' overall perspectives and opinions regarding system effectiveness. The questionnaires and interview script are available in our earlier report (Choi et al., 2025).

2.4. Statistical analyses

To examine initial effects of sensor feedback, separate paired *t*-tests were used to compare baseline postural measures (Day 1) against each of the first three days of feedback (Day 2, Day 3, and Day 4), with effect sizes reported as Cohen's *d*. To examine longer-term effects, we fit mixed-effects regression models. Fixed effects in these models included *Workday*, *Seniority*, *Shift*, *Sex*, and *Job Title*. Based on our research focus, two-way interactions involving *Workday* were also included (*Workday* × *Shift*, *Workday* × *Sex*, and *Workday* × *Job Title*). To account for repeated observations, random intercepts and random slopes for *Workday* were included for each participant. The model's covariance structure was specified to account for variance differences between different *Job Titles*. For the usability ratings, we analyzed each individual question using a one-way, repeated-measures analysis of variance (ANOVA) across three *assessment days* (Day 2, Day 6, and Day 30), with significant main effects further explored using Tukey's HSD *post hoc* comparisons (Montgomery, 2017) and with effect sizes reported as partial eta-squared (η_{p}^2). Parametric methods were chosen for the Likert scale data, since this approach is considered robust (Rickards et al., 2012; Mircioiu and Atkinson, 2017). Since evidence on the long-term effects of postural feedback systems in real-world industrial settings is still scarce, we used a significance criterion of $p < 0.1$ to identify potentially meaningful trends. All analyses were performed using JMP Pro 18 (SAS, NC, USA). Given the purpose of this study, the results and discussion focus on the effects of *Workday*. Summaries of all statistical outcomes (paired *t*-tests, mixed-effects models, and repeated-measures ANOVA) are provided in Appendix B.

3. RESULTS

3.1. Initial effects

Across all objective measures, paired *t*-tests comparing baseline (Day 1) with the subsequent three days of feedback (Days 2–4) yielded no significant differences (Table B.1).

3.2. Long-term effects

3.2.1. Frequency of events (F_{events})

Overall, the effect of *Workday* on F_{events} was not statistically significant ($\beta = -0.13$, SE = 0.434, $p = 0.764$), indicating no overall increasing or decreasing trend in events throughout the study (Fig. 2). However, a significant *Job Title* × *Workday* interaction was observed (Table B.2), indicating that FLO workers had a significantly greater increase in F_{events} over workdays compared with both MCO and GFO workers, whereas no significant slope difference was observed between MCO and GFO workers (Fig. 3). There was also a significant main effect of *Job Title* (Fig. B.1). Compared to MCO workers, GFO and FLO workers had 40.7 and 16.6% lower F_{events}, respectively.

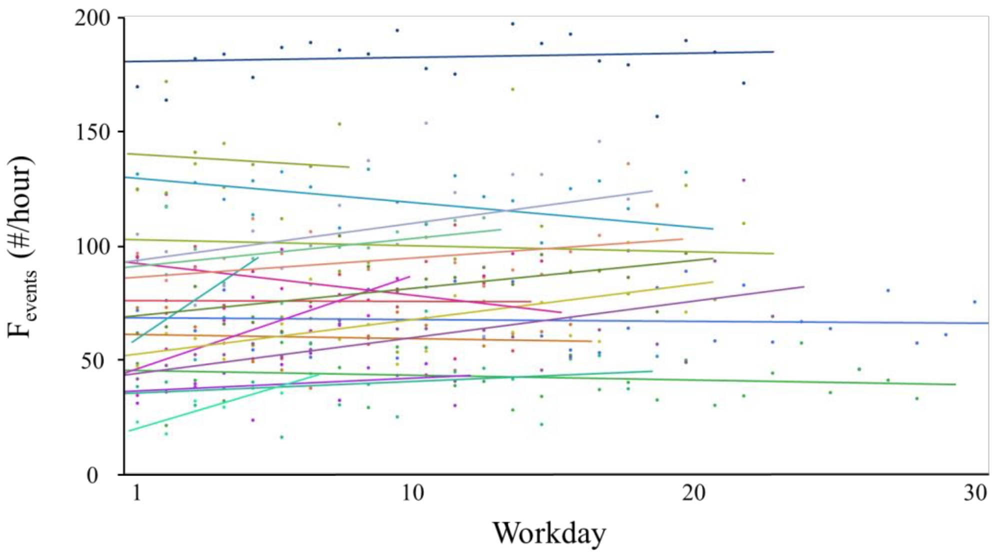

Fig. 2. Frequency of events (F_{events}: flexion >30˚) over time. Each regression line represents one participant. Day 1 represents the baseline measurement, during which no feedback was provided.

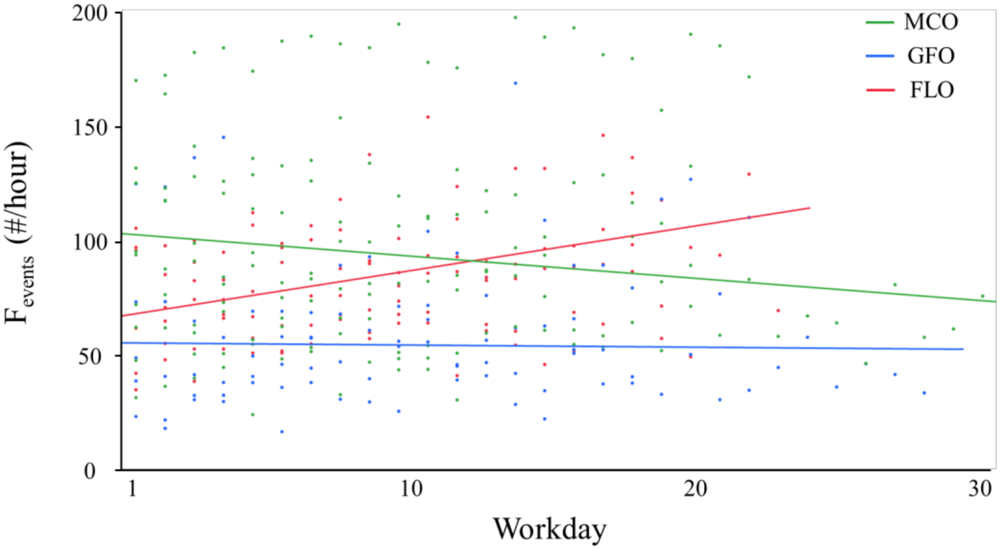

Fig. 3. *Job Title* × *Workday* interaction effect on frequency of events (F_{events}: flexion > 30˚). Day 1 represents the baseline measurement, during which no feedback was provided.

3.2.2. Frequency of hazards ($F_{hazards}$)

The effect of *Workday* on F_{hazards} was not statistically significant ($\beta = 0.06$, SE = 0.204, $p = 0.769$; Fig. 4). However, there were significant effects of *Shift* ($\beta = –4.90$, SE = 2.37, $p = 0.061$) and *Job Title*. Workers on the receiving shift performed 73.2% fewer hazardous trunk flexions than those on the shipping shift (Fig. B.2). In addition, MCO workers exhibited 32.8% more hazardous trunk flexions than FLO workers ($\beta = –5.75$, SE = 2.21, $p = 0.022$; Fig. B.3).

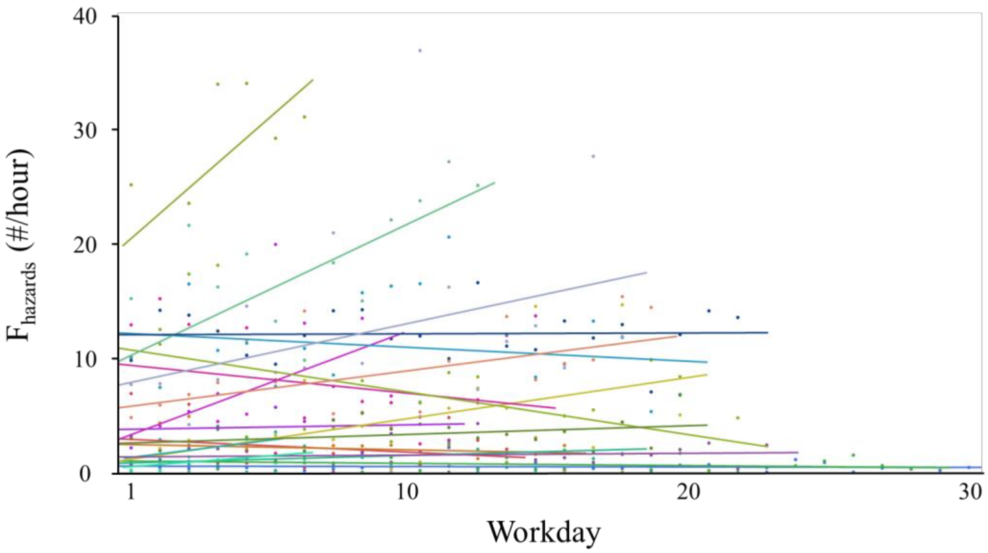

Fig. 4. Frequency of hazards (F_{hazards}: flexion >85˚) over time. Each regression line represents one participant. Day 1 represents the baseline measurement, during which no feedback was provided.

3.2.3. Peak angle during events (A_{events})

There was not a significant effect of *Workday* on A_{events} ($\beta = 0.07$, SE = 0.11, $p = 0.539$; Fig. 5). However, a significant *Job Title* × *Workday* interaction was observed (Table B.2). Specifically, the slope for FLO workers increased over workdays and was significantly greater than that for GFO workers, whereas no significant differences in slopes were found between MCO and GFO workers or between MCO and FLO workers (Fig. 6). There was an effect of *Sex* ($\beta = 4.19$, SE = 1.96, $p = 0.054$), with female workers having ~9.5% greater peak angles during events (Fig. B.4). In terms of *Job Title*, significant differences were found for both GFOs and FLOs in comparison with MCOs (Table B.2). GFO workers had 10% smaller peak angles during events, while FLO workers had 2.6% lower peak angles during events (Fig. B.5).

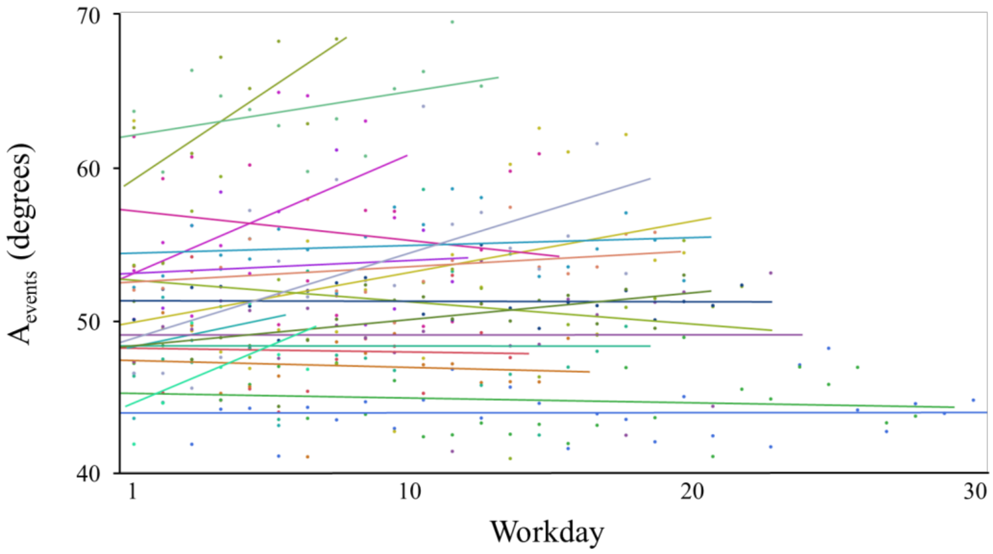

Fig. 5. Peak angle during events (A_{events}) over time. Each regression line represents one participant. Day 1 represents the baseline measurement, during which no feedback was provided.

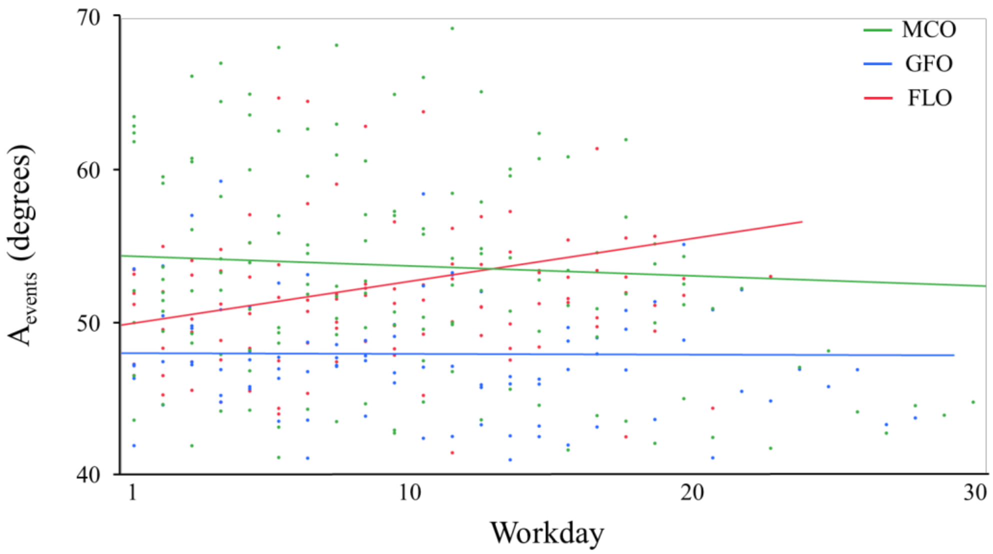

Fig. 6. *Job Title* × *Workday* interaction effect on peak angle during events (A_{events}). Day 1 represents the baseline measurement, during which no feedback was provided.

3.2.4. Peak angle during hazards ($A_{hazards}$)

The effect of *Workday* on $A_{hazards}$ was not statistically significant ($\beta = -0.05$, SE = 0.07, $p = 0.550$; Fig. 7). However, there was a significant *Sex* × *Workday* interaction ($\beta = -0.27$, SE = 0.11, $p = 0.029$; Fig. 8). $A_{hazards}$ did not change over time among female workers ($\beta = -0.05$), whereas male workers had a negative slope, reflecting a slight decrease in $A_{hazards}$ over the study period.

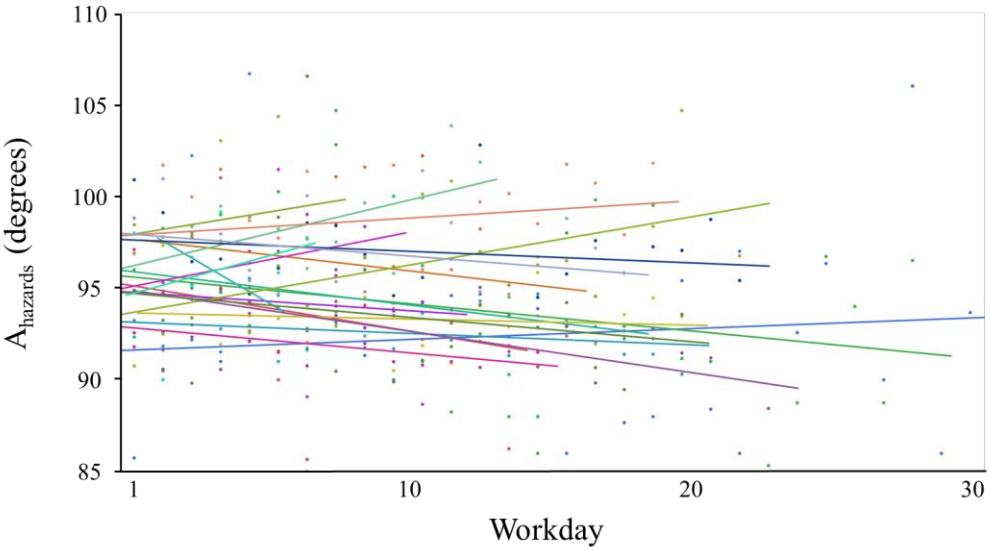

Fig. 7. Peak angle during hazards ($A_{hazards}$) over time. Each regression line represents one participant. Day 1 represents the baseline measurement, during which no feedback was provided.

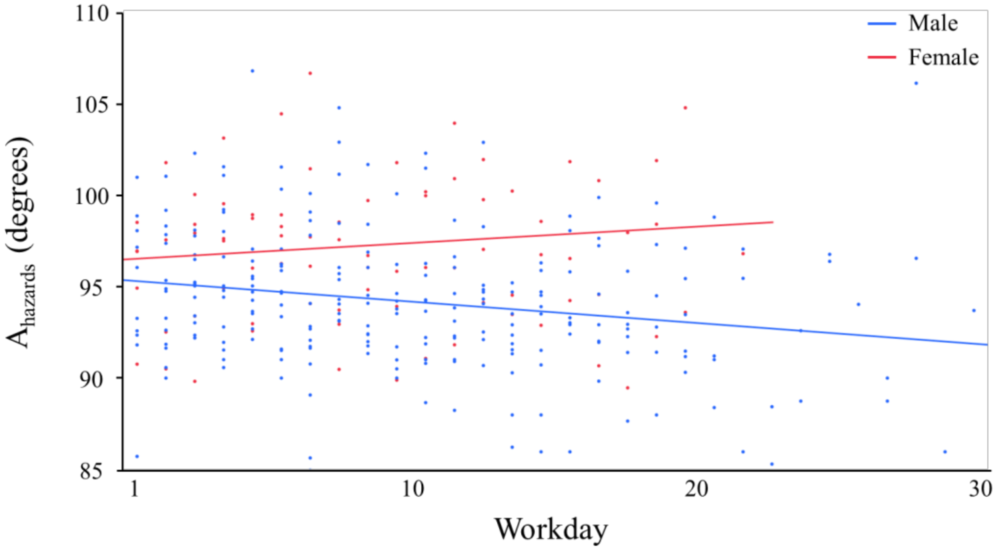

Fig. 8. *Gender* × *Workday* interaction effect on peak angle during hazards ($A_{hazards}$). Day 1 represents the baseline measurement, during which no feedback was provided.

3.3. Usability ratings

Across all usability questions, mean scores were consistently above 5 on the 7-point scale, reflecting generally positive perceptions of the system (Fig. B.6). Most questionnaire items did not show significant changes across assessment days (Table B.3). However, there was a significant change in comfort with the system, and subsequent *post hoc* comparisons indicated that comfort ratings significantly decreased from Day 2 to Day 30 (Fig. 9).

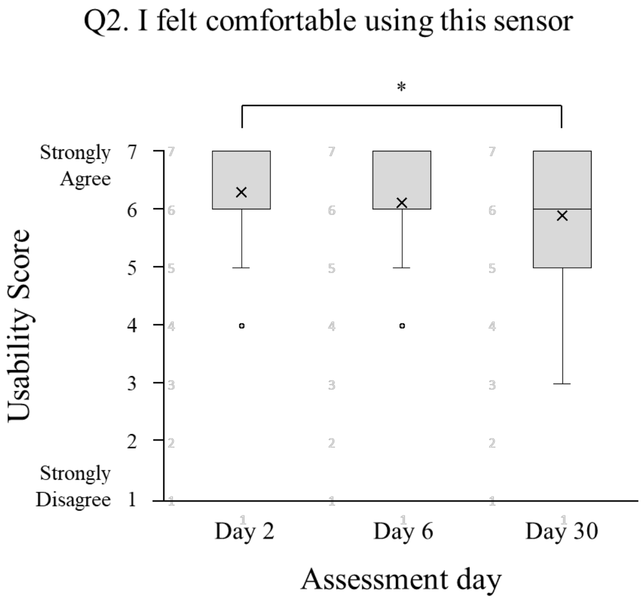

Fig. 9. Usability ratings for comfort across assessment days (Day 2, Day 6, Day 30). The asterisk (*) indicates a significant paired difference.

4. DISCUSSION

We evaluated the effectiveness of a commercial postural feedback system in a logistics environment. Our first hypothesis, that the postural feedback system would lead to initial improvements, was not supported. We found no significant differences in any of the objective outcome measures between baseline and the first few days of feedback engagement (Table B.1). We completed additional analyses to examine whether there were any temporal trends in mean or median values, but no consistent pattern was observed. This absence of improvements contrasts with previous studies that, even with shorter feedback engagement periods (e.g., 4 min–1 hr), demonstrated reductions of 34–80% in trunk flexion angle (Lind et al., 2023b), decreases of 30–55% in the time spent in trunk inclination (Lind et al., 2020b), and fewer "risky" postures identified by ergonomic risk assessments (Battini et al., 2014; Cerqueira et al., 2020). Further, our earlier field study also reported reductions in both the frequency and magnitude of hazardous trunk flexion during feedback use (Choi et al., 2025), though not statistically tested. Despite our objective findings, subjective responses suggested that the majority of workers perceived the feedback as useful in enhancing their awareness of working postures, with comments such as "the vibration gets my attention" or "the sensor makes me aware of my movements at all times." However, these perceived benefits were not reflected in the objective posture metrics, suggesting a possible dissociation between awareness and behavioral change.

Our second hypothesis was that using the postural feedback system would result in sustained or consistent reductions in postural exposures over time. This hypothesis was partially supported. Although the main effect of *Workday* was not statistically significant for the objective measures, a significant *Sex* × *Workday* interaction effect was observed for A_{hazards} (Fig. 8). Overall, the frequency and magnitude of hazardous trunk flexion did not change significantly over time. The absence of postural improvement may partly reflect substantial variability across participants. As shown in Figures 4–7, for example, some workers exhibited substantially increasing slopes over workdays, whereas others maintained flat or decreasing slopes. However, the significant *Sex* × *Workday* interaction for $A_{hazards}$ indicated that male workers exhibited a decreasing trend in hazardous trunk flexion angle over workdays (Fig. 8). This difference may be attributable to the smaller number of females in our sample, but could also reflect differences in work strategies, body mechanics, or task assignments between male and female workers, though further investigation is needed to clarify these mechanisms. To explore additional sources of variability, we examined participant characteristics such as age, seniority, job title, and shift assignment. However, no consistent patterns were identified that could explain why certain workers showed greater increases in postural exposures over time. Additional information, such as specific task assignments or physical capacity, may be needed to better understand these individual differences. Importantly, the absence of sustained behavioral changes in our study should not be interpreted as a general conclusion about postural feedback systems. Rather, the findings may reflect a combination of factors related to the particular system and task conditions evaluated here, including potential sensor inaccuracy, manufacturer-defined feedback thresholds, and the extent to which the detected postures were actually modifiable within the demands of the job. More refined or context-aware feedback systems, along with rigorous validation of sensing capability, may be required to effectively support sustained postural changes in such work environments.

Prior studies that evaluated the postural feedback system in field settings lasting more than one month also obtained similar results. For example, Ribeiro et al. (2020) tested an auditory feedback system among healthcare workers over a four-week period and found no reductions in time spent in trunk flexion postures greater than 45°, nor any differences in four follow-up assessments during the subsequent year. Similarly, Lind et al. (2023b) observed immediate reductions in trunk inclination among warehouse workers when vibrotactile feedback was first introduced, but these improvements diminished at one- and three-week follow-ups once feedback was removed. This lack of sustained improvement parallels a broader challenge documented in ergonomic training research. Lavender et al. (2007) emphasized that exposure to training alone does not produce lasting behavioral change, and that some degree of proficiency during the learning process is necessary for improvements to persist. Importantly, prior studies evaluated feedback systems during relatively short or intermittent periods of use (Kent et al., 2023; Au et al., 2025), whereas workers in the present study engaged with the system *continuously* throughout their work shifts. Even with this extended exposure, no sustained improvements in trunk posture were observed. Future studies should examine the role of motor learning principles—such as for optimizing feedback design to promote sustained postural adaptation—while also investigating diverse occupational settings and alternative feedback architectures. Such work would help clarify the conditions under which these systems can most effectively facilitate meaningful and lasting postural improvements. Additionally, future research should consider whether feedback systems are better suited as temporary or even intermittent training tools to establish improved movement patterns rather than as *continuous* monitoring and feedback devices.

Despite the lack of objective improvement, participants' overall perceptions of the system were positive. Qualitative feedback they provided, however, helps explain why these positive perceptions did not translate into behavioral change. Three key themes emerged. First, the physical demands of the job likely constrained workers' ability to modify their posture. Workers reported that the system often gave alarms “during movements that are part of the job and cannot be avoided,” suggesting that many “hazardous” postures were, in fact, necessary to complete their tasks. Thus, a simple feedback system may be ineffective if the work itself is not designed to permit alternative, safer movements. Second, substantial inter-individual variability likely masked any potential overall effects. This variability was reflected in the participant comments. For example, some noted entrenched habits (“I just tend to do the same thing I’ve always done”), while others were more open to change. A divergence in attitude and behavior, combined with variability in our objective postural data, underscores the limitations of a one-size-fits-all feedback strategy. Finally, the worker feedback supports the idea that the “initial benefits” seen in earlier studies with short engagement times may reflect transient novelty effects. Workers here reported an immediate increase in awareness, noting that “the vibration gets your attention.” While this heightened awareness is often assumed to drive improvement, our findings show it did not, suggesting that the initial novelty of being monitored may wear off quickly without leading to sustainable change.

Usability results here also showed that participants had a positive impression of the postural feedback system. Usability scores suggest that workers perceived the system as easy to use, non-disruptive, reliable, and supporting their awareness of body movements during work (Fig. B.6). Although overall perceptions of system usability were highly favorable, ratings on comfort (i.e., “I felt comfortable using this sensor”) declined significantly from Day 2 to Day 30 (Fig. 9), indicating certain aspects such as long-term comfort may warrant further refinement in future system designs.

Nevertheless, such subjective evaluations should be interpreted with caution. Participants may have felt inclined to provide favorable answers to align with perceived expectations (e.g., Arnold and Feldman, 1981). Accordingly, positive usability ratings might be better viewed as indicators of acceptability rather than conclusive evidence of ergonomic effectiveness.

The postural feedback system we used was a single-sensor system that quantified trunk flexion. Trunk flexion measured from a single sensor primarily reflects global trunk orientation relative to gravity, whereas segment-specific lumbar flexion represents motion occurring between adjacent spinal segments. Previous research has explored multi-sensor approaches to better distinguish global trunk inclination from segment-specific lumbar spine flexion (Doss et al., 2018). By computing the relative orientation between the pelvis and trunk segments, such systems can more directly estimate lumbar spine motion independent of hip flexion. Doing so enables more precise identification of whether a worker is maintaining a neutral spine while bending, potentially supporting technique-focused feedback aimed at promoting hip hinge strategies rather than simply limiting overall trunk inclination. In real occupational contexts, however, increasing the number of sensors may introduce practical challenges, including variability in sensor placement, greater calibration demands, and reduced usability during full work shifts (Figueira et al., 2024; Lind, 2024a).

Some limitations of this study should be noted. First, although participants had relatively consistent daily work demands according to facility leaders, the baseline data collected over a single day may not have fully captured the variability in work tasks, effort, or fatigue that could occur over longer periods. Second, we evaluated a single commercial feedback system with proprietary algorithms and a single set of feedback approaches. Future work is needed to determine whether alternative feedback approaches might yield different or more effective outcomes. Third, while we adhered to manufacturer instructions and applied filtering procedures to minimize noise, sensor movement due to loose clothing or inconsistent placement may still have introduced measurement errors in the recorded trunk motions, since the sensors were clipped to the garment rather than attached directly to the skin. Fourth, our current study did not include a formal validation of the sensor system (e.g., against an optical motion capture reference). Although prior evidence suggests that modern IMU systems can achieve reasonable accuracy in measuring trunk flexion during complex tasks (e.g., Picerno et al., 2021; McClintock et al., 2024), uncertainty in measurement precision could have influenced the observed effectiveness. Future research integrating independent validation with longitudinal field evaluation would provide a more comprehensive understanding of the real-world effectiveness of postural feedback systems. Lastly, workers who discontinued participation during the study may have differed from those who completed the study in their exposure levels or responses to the feedback system. Future studies with larger samples may benefit from more formal attrition analyses.

In summary, we evaluated the effects of a commercial postural feedback system among logistics workers in an auto-parts distribution center for up to six weeks. Across most objective outcome measures, no clear initial or sustained improvements were observed over the period of use; however, for hazardous trunk flexion angle (A_{hazards}), male workers showed a decreasing trend over the study period. This suggests that the system, as currently implemented, did not result in consistent measurable ergonomic benefits. Such results could reflect limitations in the particular system design and its implementation in a demanding work setting, which could be addressed through refinements in feedback algorithms and detection sensitivity, as well as validation of system sensing capability. On the other hand, participants reported highly favorable perceptions of the system, noting that it was easy to use, non-disruptive, and supportive of their work. Future research should pursue extended deployments, such as the 6-week period used in this study, in diverse occupational contexts and apply rigorous evaluation approaches that integrate both objective posture metrics and subjective experiences to clarify the practical potential of postural feedback systems. In particular, developing context-aware feedback algorithms that can distinguish between unavoidable and modifiable postures may promote sustained behavioral change in industrial work environments.

Declaration of generative AI and AI-assisted technologies

During the preparation of this work the author(s) used ChatGPT 5.0 in order to improve the clarity and readability of the manuscript. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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DEDICATION

This work is dedicated to the memory of Mr. Chris Thomason (UAW-GM) whose contributions to this study were invaluable and whose presence will be deeply missed.

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