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Integration of Myotonometry and Eye Tracking as Objective Assessment of Intensive Display-Based Office Work

Zenija Roja[1], Henrijs Kalkis[1, 2], Liga Ozolina-Molla[2], Tatjana Pladere[3], Linda Krauze[3], Reinis Alksnis[4], and Jevgenijs Viznuks[2]

[1]University of Latvia, Faculty of Economics and Social Sciences, Aspazijas blvd.5, LV 1050, Riga, Latvia
[2]University of Latvia, Department of Human Factors and Work Environment, Faculty of Medicine and Life Sciences, Jelgavas street 1, LV 1004, Riga, Latvia
[3]University of Latvia, Department of Optometry and Vision Science, Faculty of Science and Technology, Jelgavas street 1, LV 1004, Riga, Latvia
[4]University of Latvia, Laboratory of Statistical Research and Data Analysis, Faculty of Science and Technology, Jelgavas street 1, LV 1004, Riga, Latvia

ABSTRACT

Intensive display-based office work may result in short-term changes in both the musculoskeletal and visual systems, yet day-to-day workplace screening rarely relies on objective measures. This field study examined the feasibility and sensitivity of a brief protocol combining myotonometry and wearable eye tracking to capture within-day and across-day variation during three consecutive workdays in an ergonomically advanced office. Myotonometry outcomes are presented for a female subsample (n = 17), while eye-tracking indicators are summarized for the full cohort (n = 31). Myotonometric assessments targeted superficial upper-limb and shoulder muscles and focused on mechanical properties reflecting muscle tone and stiffness. Eye tracking captured viewing behavior and saccade dynamics during typical screen-based tasks. Across the three-day period, myotonometry indicated repeatable time-of-day shifts consistent with increasing neuromuscular loading, with patterns varying by muscle group. Eye-tracking metrics showed progressive changes compatible with time-on-task and cumulative visual-cognitive strain, including lower afternoon saccadic velocities and longer fixation durations by Day 3. Taken together, the findings suggest that integrating myotonometry with wearable eye tracking can reveal early, subclinical signatures of intensive digital work, even when ergonomics are considered optimized. Such multisystem monitoring may complement self-reports and support evidence-based micro-interventions (e.g., task redesign, micro-break scheduling, and individualized workstation coaching).

Keywords: Office ergonomics, Myotonometry, Eye tracking, Viewing behavior, Muscle tone, Brief monitoring

INTRODUCTION

Display-based office work is increasingly intensive, driven by rapid digitalization and the use of multiple screens, prolonged static postures,

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and high cognitive demand. These conditions can contribute to cumulative upper-body loading and visual strain that may not be captured by periodic questionnaires alone. Objective, low-burden tools such as myotonometry have a long history in ergonomics research for tracking muscle functional state in real work settings (Roja et al., 2006; Roja et al., 2015). This a non-invasive method used to measure the biomechanical and viscoelastic properties of superficial muscles allows quantifying muscle stiffness, tone, elasticity, and relaxation time by applying a brief, perpendicular force to skin.Recent studies highlights how ergonomic and psychosocial risks can translate into measurable performance-related outcomes in office populations (Kalkis et al., 2025). Building on this background, the aim was to examine whether a short multimodal protocol can detect within-day and across-day changes during intensive display-based work. Digital eye strain and computer vision syndrome remain highly prevalent among intensive computer users, with reviews reporting symptoms in a large proportion of office workers (Sheppard & Wolffsohn, 2018; Rosenfield, 2011).

METHODS

Participants and setting. The original field protocol enrolled 31 office employees; to differentiate this conference paper from the source manuscript, we report a focused sub-analysis of the female subgroup (n = 17; mean age 33.0 ± 4.4 years; BMI 23.0 ± 3.5 kg/m^2; right-hand dominant: 16/17). The study took place in a modern Information Technology (IT) company's office with flexible workstations and high daily screen exposure. The research protocol was approved by the University of Latvia Life and Medical Sciences Research Ethics Committee (No. 1-12/46, 25 Apr 2025); all participants provided written informed consent.

Procedure. Measurements were collected twice daily over three consecutive workdays: morning (09:00–11:00) and afternoon (16:00–18:00). Each modality required approximately 5-10 minutes. Between sessions, employees continued their usual work, including at least six hours of display-based work.

Myotonometry. Superficial muscle mechanical properties were assessed with a MyotonPRO device (Myoton AS, Estonia) using the mechanical impulse method. Measurements were taken bilaterally for the upper trapezius, extensor digitorum, and flexor carpi radialis with participants seated and muscles relaxed; three repetitions per site were averaged.

Wearable eye tracking. Viewing behavior and blinking were recorded with Neon eye-tracking glasses (Pupil Labs GmbH, Germany; 200 Hz). After gaze offset correction, participants completed a standardized computer-based task (digital Wisconsin Card Sorting Test), allowing comparable recordings across sessions.

Statistical analysis. Time-of-day and day effects were tested using linear mixed-effects models with participant-specific random effects. Models were implemented in R using lme4 and related packages (Bates et al., 2015; Kuznetsova et al., 2017; Lenth, 2024).

Table 1: Characteristics of the female subsample used for myotonometry analysis.

Group	n	Age (Years) Mean ± SD	BMI (kg/m^2) Mean ± SD	Dominant Hand Right	Dominant Hand Left
Females	17	33.0 ± 4.4	23.0 ± 3.5	16	1

RESULTS

Myotonometry (female subsample, n = 17; Table 1) indicated consistent time-of-day variation across the monitored muscles. Across measurement days, indicators of muscle mechanical state tended to shift between morning and afternoon, suggesting accumulation of low-level neuromuscular loading during intensive display-based work. Statistically significant changes were observed in the upper trapezius and extensor digitorum. The trapezius oscillation frequency was significantly lower in the afternoon than in the morning on the dominant side ($\beta = -0.30$, $p = 0.02$), while the opposite effect appeared in extensor digitorum, where the frequency was higher in the afternoon compared to the morning (dominant: $\beta = 0.51$, $p < 0.001$; non-dominant: $\beta = 0.35$, $p = 0.02$). Stiffness values decreased significantly in the trapezius dominant hand ($\beta = -0.34$, $p = 0.01$), but increased in the extensor digitorum (dominant hand $\beta = 0.61$, $p < 0.001$) in the afternoon compared to the morning. Relaxation time showed significant differences across the workdays. It increased in the afternoon compared to the morning in the trapezius ($\beta = 0.34$, $p = 0.01$), but the opposite trend was found in the extensor digitorum, where relaxation time decreased after display-based work in both hands (dominant $\beta = -0.52$, $p < 0.001$; non-dominant $\beta = -0.33$, $p = 0.04$).The observed direction of change differed by muscle group, which is compatible with different roles in posture stabilization (e.g., shoulder/neck region) versus fine motor control (forearm extensors).

Eye-tracking results (Table 2) demonstrated small but systematic changes across days and within days. From Day 1 morning to Day 3 afternoon, fixation duration increased (median from 385 ms to 439 ms), suggesting slower gaze stabilization and/or greater processing time per fixation during prolonged work.

Saccade mean velocity and peak velocity showed lower afternoon values relative to morning on both Day 1 and Day 3 (e.g., mean velocity 133°/s in Day 1 morning vs 129°/s in Day 1 afternoon; 133°/s in Day 3 morning vs 126°/s in Day 3 afternoon). Peak velocity followed a similar pattern (220°/s vs 209°/s on Day 1; 217°/s vs 207°/s on Day 3). Saccade amplitude remained comparatively stable across sessions, indicating that velocity shifts were not driven by gross changes in movement size.

Overall, the eye-movement profile is compatible with time-on-task effects in visually demanding work, where oculomotor dynamics and fixation behavior gradually drift during sustained screen interaction. These descriptive findings provide the empirical basis for the mechanistic interpretation developed below.

Table 2: Selected eye-tracking indicators (median [Q1–Q3]) for the full cohort across days.

Indicator	Day 1 Morning	Day 1 Afternoon	Day 3 Morning	Day 3 Afternoon
Saccade amplitude (°)	5.3 [4.9–5.8]	5.1 [4.5–5.7]	5.4 [5.0–5.8]	5.4 [4.8–5.9]
Saccade mean velocity (°/s)	133 [124–140]	129 [118–138]	133 [117–140]	126 [116–139]
Saccade peak velocity (°/s)	220 [198–235]	209 [189–235]	217 [196–246]	207 [186–239]
Fixation duration (ms)	385 [339–433]	417 [358–470]	414 [360–522]	439 [363–501]

DISCUSSION

This study supports the practical value of combining two brief, objective modalities to capture early and potentially subclinical responses to intensive digital work. The within-day shifts observed in the myotonometry subsample align with the premise that sustained low-force activity, static postures, and repetitive mouse/keyboard use can alter superficial muscle mechanical behavior over the course of a workday. Prior myotonometry-based field research has demonstrated measurable muscle state changes under real occupational loading, including prolonged work in constrained postures and repetitive tasks (Roja et al., 2006; Roja et al., 2015). In office contexts, myotonometry has also been used to evaluate trapezius tone and its responsiveness to workplace interventions (Villanueva et al., 2020), supporting feasibility for prevention-oriented monitoring.

The eye-tracking trends extend this multisystem perspective. Reduced afternoon saccadic velocity and increased fixation duration are consistent with earlier findings that oculomotor dynamics vary with workload and time-on-task. Reviews and experimental studies have linked changes in saccadic velocity to variations in arousal and mental effort during naturalistic tasks (Di Stasi et al., 2013), and computer-work paradigms have shown that eye-movement characteristics reflect fatigue development during prolonged screen interaction (Zargari Marandi et al., 2018). In applied settings, eye-tracking features (including saccades, blinks, and fixation patterns) have been used to estimate perceived workload and predict fatigue-related states (Wu et al., 2020; Bafna et al., 2021).

Importantly, the magnitude of the observed shifts in Table 2 is modest, which is expected in an ergonomically advanced office and in a relatively young cohort. However, small changes may still be meaningful for early detection when measurements are repeatable and interpreted longitudinally within individuals. This aligns with the rationale behind early-warning approaches in ergonomics: monitoring trajectories rather than relying on single-threshold symptom reports. In banking and other high-intensity knowledge-work settings, research evidence has highlighted the combined role of physical and mental load in shaping worker well-being and performance (Kalkis & Roja, 2025a; Kalkis & Roja, 2025b). The present multimodal protocol provides a complementary, objective layer that can be integrated with psychosocial and organizational risk assessments. From a clinical perspective, integrating myotonometry and eye tracking offers a promising approach to the early identification of subtle neuromuscular and oculomotor changes that may precede overt musculoskeletal or visual complaints in screen-intensive daily work. By enabling repeated and minimally disruptive monitoring in real work environments, this combined methodology could facilitate more timely preventive interventions before strain progresses to clinically relevant dysfunction.

From a mechanistic standpoint, myotonometry and eye tracking may capture different but interacting pathways of workload. Musculoskeletal responses can arise from sustained activation of postural stabilizers, altered motor-unit recruitment, and reduced opportunities for recovery during prolonged sitting and pointing tasks. In parallel, visual-cognitive strain may manifest as increased fixation time (greater processing demand), changes in saccadic dynamics (arousal and effort), and altered scanning strategies as fatigue accumulates. Multimodal monitoring can therefore support a richer interpretation than either modality alone, especially when triangulated with contextual information (task type, meeting density, screen time, and break behavior).

An additional advantage of the combined approach is that it supports multilevel modeling and personalization. Rather than treating fatigue or strain as a single construct, future analyses can model oculomotor and myotonometric features as parallel time series, estimate within-person baselines, and quantify departures associated with specific task episodes (e.g., intensive email processing, long video meetings, or high-precision spreadsheet work). This opens a pathway toward practical digital-ergonomics dashboards in which objective signals are interpreted together with contextual metadata (application use, input-device activity, and break patterns) to guide timely recovery actions.

Several limitations should be noted. First, myotonometry outcomes in this research are presented for a female subsample to differentiate this conference paper from the parent manuscript and to keep the analysis coherent; sex-stratified models with larger samples are needed to test interaction effects robustly. Second, the protocol captures short-term variation over three days; longer follow-up is required to link objective drift patterns to symptom onset, productivity outcomes, or clinical endpoints. Third, while the office was ergonomically advanced, micro-variations in workstation settings, task demands, and individual work style can still influence outcomes and should be modeled explicitly in future work.

Despite these constraints, the findings encourage practical application. Routine deployment could prioritize high-risk periods (e.g., extended computer sessions, peak reporting deadlines) and focus on individualized trends. Future studies should evaluate whether providing feedback (for example, micro-break prompts triggered by oculomotor drift) and targeted ergonomics coaching reduces both objective load indicators and downstream musculoskeletal or visual complaints, consistent with intervention-oriented workplace ergonomics programs (Cardoso et al., 2025).

From an organizational perspective, the proposed monitoring logic is compatible with a 'human-centred performance' framing: objective signals can be used to support recovery and sustainable productivity rather than to evaluate individuals. In practice, implementation should emphasize transparency, voluntary participation, and aggregation at team level when informing process or workstation changes. Integrating the protocol with standard ergonomic risk-management workflows (workstation audits, task analysis, and psychosocial risk screening) could enable a pragmatic tiered approach: (1) low-burden periodic screening for groups with intensive screen time; (2) targeted assessment for individuals reporting early symptoms; and (3) evaluation of intervention effectiveness via before–after trajectories. Finally, the same multimodal framework can be extended by incorporating subjective visual discomfort ratings, short cognitive tasks, or passive device-based activity metrics to improve interpretability and to support actionable thresholds.

CONCLUSION

A brief, non-invasive protocol combining myotonometry and wearable eye tracking captured systematic within-day and across-day variation during intensive display-based office work. Even in an ergonomically advanced environment, objective indicators suggested measurable drift in muscle mechanical state and oculomotor behavior that is compatible with early micro-fatigue. Future research should expand the sample size to enable robust sex- and age-stratified modelling, link multisystem trajectories to validated symptom scales and productivity outcomes, and test intervention strategies (task redesign, micro-break algorithms, and individualized coaching) using randomized or stepped-wedge workplace designs.

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