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Computerized PsychoPy-based Assessment of Audio-Visual Reaction Time Across Physical Activity Patterns Among Adult Workers: A Cross-Sectional Study

Dilasa Lekhraj Jaiswal[1], Sheetal Salvi[2] and Anuradha Rajiv Joshi[3]
[1-3]Bharati Vidyapeeth (Deemed to be University), Department of Physiology, Pune, India
Email: dilasa1306@gmail.com, dilasa.jaiswal-mcp@bharatividyapeeth.edu

***Abstract*— Sedentary behaviour is increasingly associated with impaired sensorimotor and metabolic health in working adults. This cross-sectional analytical study evaluated audio-visual reaction time across physical activity patterns among adult workers using a computerized PsychoPy-based experimental paradigm. A total of 120 participants were categorized into sedentary and non-sedentary groups based on habitual activity patterns. Auditory reaction time (ART) and visual reaction time (VRT) were recorded under standardized testing conditions using computerized stimulus presentation, randomized foreperiods, keyboard-based response capture, and millisecond-resolution timing. Fasting blood glucose was also assessed to examine associated metabolic differences. In the overall sample, ART was significantly shorter than VRT, indicating faster processing of auditory stimuli. Sedentary individuals showed significantly prolonged VRT compared with non-sedentary individuals and significantly prolonged ART. Fasting blood glucose was also higher in the sedentary group. These findings suggest that sedentary activity patterns are associated with delayed computerized reaction-time performance and altered metabolic status among adult workers.**

***Index Terms*— PsychoPy, computerized reaction time assessment, auditory reaction time, visual reaction time, sedentary behaviour, physical activity patterns.**

I. Introduction

Physical activity patterns, including sedentary behaviour and active movement, are increasingly recognized as important determinants of overall health. Sedentary behaviour is defined as any waking activity characterized by energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture [4]. This distinction is clinically significant, as accumulating evidence demonstrates that prolonged sedentary time is associated with adverse health outcomes even after adjusting for levels of moderate-to-vigorous physical activity [9]. This is particularly relevant in occupational populations where prolonged sitting is increasingly common. From a physiological perspective, the present study integrates two interrelated domains: sensorimotor processing and cardiometabolic regulation. Reaction time represents a simple yet robust measure of central nervous system processing efficiency. It reflects the time required for stimulus detection, central processing, and execution of a motor response. Variations in auditory and visual reaction times are attributed to differences in sensory transduction pathways and neural processing speeds, with auditory reaction time generally observed to be shorter than visual reaction time under standardized experimental conditions [10].

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Concurrently, physical activity patterns—particularly sedentary behaviour—have been strongly linked to cardiometabolic dysregulation. Systematic reviews and meta-analyses have consistently associated prolonged sedentary exposure with an increased risk of metabolic syndrome, insulin resistance, and type 2 diabetes [11]. Glycaemic regulation, in particular, has been proposed as a key mechanistic pathway linking activity patterns to alterations in brain function and cognitive performance [12]. Physical activity appears to exert beneficial effects across both domains. Regular exercise improves insulin sensitivity and glucose homeostasis, while also enhancing cerebrovascular function and promoting neuroplasticity through mechanisms involving neurotrophic factors. These adaptations may contribute to improved cognitive efficiency and faster sensorimotor responses[13]. Despite this growing body of evidence, there remains a relative paucity of studies that simultaneously evaluate both neurophysiological (reaction time) and metabolic (fasting blood glucose) parameters in relation to physical activity patterns, particularly within occupational settings. Understanding this neuro-metabolic interaction may provide clinically relevant insights into early functional alterations associated with modern sedentary lifestyles. Therefore, the present study aimed to evaluate the association of physical activity patterns with audio-visual reaction time and fasting blood glucose levels among adult workers. Specifically, the study assessed auditory and visual reaction times using a standardized protocol and compared these parameters, along with fasting blood glucose levels, between sedentary and non-sedentary individuals to explore potential neuro-metabolic interactions.

II. Materials and Methods

Study design, setting, and duration: A cross-sectional analytical study was conducted in a tertiary care setting over a period of one year. The study design and reporting were aligned with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies [1].

Participants, eligibility criteria, and sampling: The study included employed adult workers with a minimum of six years of occupational experience who provided informed consent. Exclusion criteria included individuals with less than six years of work experience, known neurological disorders, cognitive impairment, or diagnosed diabetes mellitus, in order to minimize confounding due to disease-related neurocognitive and metabolic alterations [15]. A non-probability sampling technique was employed as per study protocol. While operationally feasible, this approach may introduce selection bias and limit the generalizability of findings [1].

Operational definitions and group classification: Sedentary behaviour was defined in accordance with World Health Organization guidelines as any waking behaviour characterized by energy expenditure ≤1.5 metabolic equivalents (METs) in a sitting, reclining, or lying posture [17]. Terminology was consistent with the Sedentary Behaviour Research Network consensus framework [18]. Participants were categorized as sedentary or non-sedentary based on their habitual activity patterns. Non-sedentary individuals were defined as those engaging in moderate to high levels of physical activity as part of their occupational or daily routine, representing movement-enriched behaviour in contrast to prolonged sitting patterns [4].

Study flow and procedure: Participants were screened for eligibility, categorized based on activity patterns, and subsequently subjected to standardized assessment of auditory and visual reaction times, followed by fasting blood glucose estimation. All measurements were conducted under controlled conditions as per study protocol. Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study [DHR Reg. No. EC/NEW/INST/2022/MH/0150; Approval Ref. No. BVDUMC/IEC/25-26/370E]. All participants were informed about the purpose, procedures, and nature of the study before participation.

A. Instruments and Measurements

Data capture was performed using a structured proforma to document occupational exposure, eligibility screening variables, and compliance with pre-test instructions (including caffeine avoidance). Reaction time was assessed using a computerized experimental paradigm developed in PsychoPy software. The system incorporated stimulus generation (auditory and visual), response input via a designated keyboard key, and millisecond-resolution timing through the software's internal clock. Participants were instructed to respond by pressing the assigned response key with the index finger immediately upon perception of the stimulus. Foreperiod intervals were varied randomly within the program to minimize anticipatory responses [19]. Visual stimuli were presented on a computer display in the form of colored light cues, while auditory stimuli were delivered as tone/click signals through speakers or headphones, consistent with standard physiology laboratory paradigms [10]. All measurements were conducted under standardized conditions between 11:00 and 12:00 hours in a quiet environment to minimize external distractions and diurnal variation. Participants were instructed to avoid caffeine intake prior to testing due to its known effects on reaction time performance [6]. Multiple trials were conducted for each stimulus modality within a single session, and the mean reaction time was calculated automatically by the software for analysis. Although software-based timing may be influenced by hardware latency, standardized testing conditions were maintained to minimize variability. Fasting blood glucose (FBG) was measured under fasting conditions using a glucometer. Point-of-care glucose devices are subject to predefined accuracy standards, which were considered while interpreting results [7].

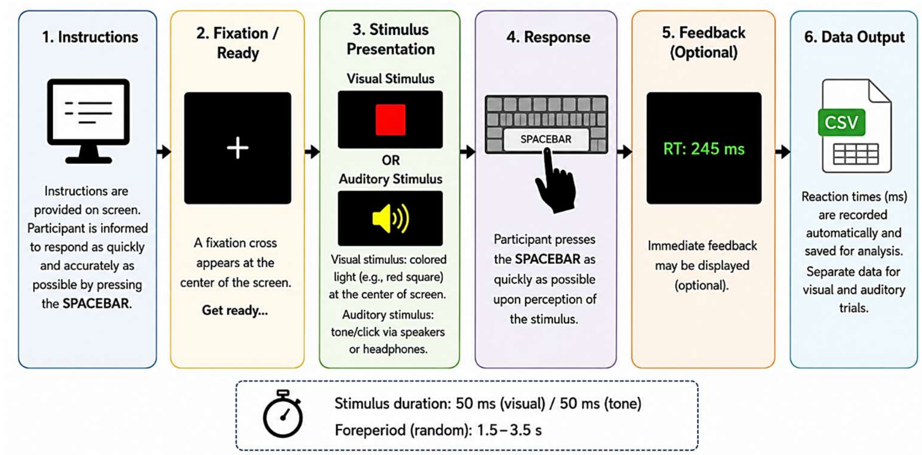

Fig.1 Schematic representation of audio-visual reaction time assessment using a computerized PsychoPy-based paradigm

B. Statistical Analysis

Data were analysed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and as median (interquartile range) for skewed distributions. Reaction time data were obtained through an automated computerized system (PsychoPy), allowing trial-wise recording and precise calculation of mean values for each participant. Comparisons between sedentary and non-sedentary groups were performed using the independent samples t-test. Welch's correction was applied where assumptions of equal variances were not met. For within-subject comparisons of auditory and visual reaction times, paired t-tests were used. Effect sizes were calculated using Hedges' g, and 95% confidence intervals (CI) for mean differences were reported to enhance interpretability beyond p-values alone [20]. A p-value of <0.05 was considered statistically significant.

III. Results

A. Reaction time by stimulus modality (overall sample)

In the overall study population (n = 120), auditory reaction time (ART) was significantly shorter than visual reaction time (VRT). The mean VRT was 247.60 ± 18.54 ms, while the mean ART was 228.01 ± 16.49 ms. The mean difference between VRT and ART was approximately 19.59 ms, which was statistically significant ($p < 0.001$).

TABLE I: Reaction Time by Stimulus Modality (Overall Sample)

Outcome	Mean ± SD (n=120)	Inference
Visual reaction time (ms)	247.60 ± 18.54	VRT > ART (p<0.001)
Auditory reaction time (ms)	228.01 ± 16.49	Mean difference (VRT−ART) ≈ 19.59 ms

B. Comparison of reaction time between activity groups

Sedentary individuals demonstrated significantly prolonged reaction times compared to non-sedentary individuals. For visual reaction time, the sedentary group had a mean of 250.12 ± 18.50 ms, whereas the non-sedentary group showed a mean of 235.00 ± 13.02 ms. The mean difference was 15.12 ms (95% CI: 8.13 to 22.11), which was statistically significant (p = 0.001) with a large effect size (Hedges' g = 0.85). Similarly, auditory reaction time was significantly higher in the sedentary group (229.80 ± 16.73 ms) compared to the non-sedentary group (219.05 ± 11.97 ms). The mean difference was 10.75 ms (95% CI: 4.35 to 17.15), which was statistically significant (p = 0.007) with a moderate effect size (Hedges' g = 0.67).

TABLE II: COMPARISON OF REACTION TIME BETWEEN ACTIVITY GROUPS

Outcome	Sedentary mean ± SD	Non-Sedentary mean ± SD	Mean difference (ms)	95% CI for difference (ms)	Hedges g	p-value	Effect Size
Visual reaction time (ms)	250.12 ± 18.50	235.00 ± 13.02	15.12	8.13 to 22.11	0.85	0.001	Large
Auditory reaction time (ms)	229.80 ± 16.73	219.05 ± 11.97	10.75	4.35 to 17.15	0.67	0.007	Moderate

C. Fasting blood glucose comparison between groups

Fasting blood glucose levels were significantly higher in sedentary individuals compared to non-sedentary individuals. The mean FBG in the sedentary group was 100.61 ± 6.08 mg/dL, whereas in the non-sedentary group it was 83.75 ± 3.54 mg/dL. The mean difference was 16.86 mg/dL (95% CI: 14.85 to 18.87), which was highly statistically significant ($p < 0.001$) with a very large effect size (Hedges' g = 2.91).

TABLE III: FASTING BLOOD GLUCOSE COMPARISON BETWEEN GROUPS

Parameter	Sedentary	Non-Sedentary	p-value
FBG (mg/dL)	100.61 ± 6.08	83.75 ± 3.54	<0.001

D. Summary of Key Findings

The present study demonstrated consistent differences in neuro-metabolic parameters between sedentary and non-sedentary adult workers. In the overall sample, auditory reaction time was significantly shorter than visual reaction time, indicating faster processing of auditory stimuli. On group-wise comparison, sedentary individuals showed significantly prolonged visual reaction time and auditory reaction time compared with non-sedentary individuals, suggesting reduced sensorimotor processing efficiency among participants with sedentary activity patterns. In addition, fasting blood glucose levels were markedly higher in the sedentary group, indicating an associated metabolic difference. The effect size was large for visual reaction time, moderate for auditory reaction time, and very large for fasting blood glucose, highlighting that the observed differences were not only statistically significant but also practically meaningful. Overall, the findings suggest that sedentary behaviour is associated with delayed computerized audio-visual reaction-time performance and altered metabolic status among adult workers.

The following fig.2 provides the Graphical Summary of Neuro-Metabolic Differences Across Physical Activity Patterns -

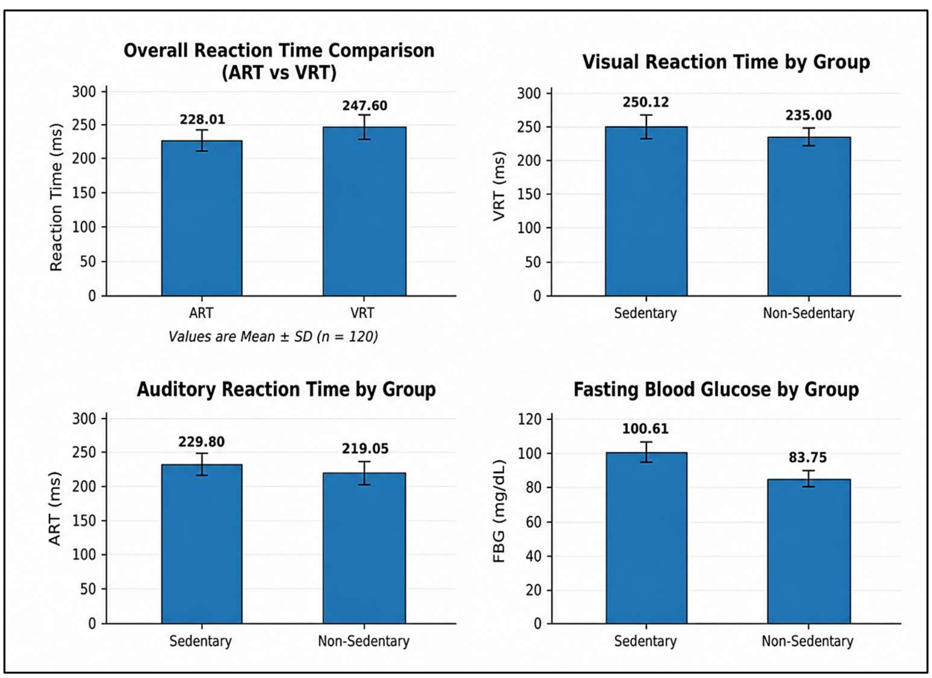

Fig.2 Graphical Summary of Neuro-Metabolic Differences Across Physical Activity Patterns.

IV. Discussion

The present study demonstrates two key findings. First, auditory reaction time was significantly shorter than visual reaction time in the overall sample. Second, individuals with sedentary activity patterns exhibited significantly prolonged auditory and visual reaction times, along with higher fasting blood glucose levels, compared to non-sedentary individuals. These findings collectively suggest a potential neuro-metabolic association linked to physical activity patterns. The observation that auditory reaction time is faster than visual reaction time is consistent with established physiological principles. Differences in sensory transduction pathways, synaptic processing, and central integration contribute to modality-specific variations in reaction time, with auditory stimuli typically processed more rapidly than visual stimuli [10]. The finding of prolonged reaction times among sedentary individuals is supported by existing evidence linking physical activity with improved cognitive and sensorimotor performance. Regular physical activity is known to enhance cerebral blood flow, improve synaptic efficiency, and promote neuroplasticity, thereby facilitating faster stimulus processing and motor response execution [21]. Neurotrophic mechanisms, including those mediated by brain-derived neurotrophic factor (BDNF), have been implicated in these exercise-induced cognitive benefits [23]. In addition to neurophysiological effects, metabolic factors may also contribute to the observed findings. Sedentary behaviour is strongly associated with impaired glucose regulation and insulin resistance, which may adversely affect brain function [12]. The significantly higher fasting blood glucose levels observed in sedentary individuals in the present study further support the role of metabolic dysregulation as a potential mediator of reduced neural processing efficiency. Experimental evidence suggests that interrupting prolonged sitting can improve glycemic responses, highlighting the dynamic relationship between activity patterns and metabolic health [24]. The use of a computerized reaction time assessment system (PsychoPy) in the present study enabled automated stimulus presentation, randomized inter-stimulus intervals, and precise millisecond-level response recording. This approach enhances data consistency and reduces manual recording errors, thereby improving the reliability of reaction time measurements. The present findings are consistent with broader epidemiological evidence demonstrating associations between sedentary behaviour and adverse cardiometabolic outcomes [26]. Furthermore, previous experimental studies have reported shorter auditory reaction times compared to visual reaction times, reinforcing the validity of the observed modality differences [10]. The integration of both neurophysiological and metabolic parameters in this study provides a more comprehensive understanding of the functional impact of physical activity patterns. However, certain limitations should be considered while interpreting the results. The cross-sectional design precludes causal inference, and the observed associations cannot establish directionality [1]. The use of non-probability sampling and recruitment from a tertiary care setting may limit generalizability. Additionally, although computerized systems provide automated and precise timing, reaction time measurements may be influenced by hardware-related latency, including keyboard response delay and display refresh rate. Future studies should incorporate objective assessment of physical activity and sedentary behaviour, such as accelerometry, to reduce exposure misclassification. Inclusion of additional metabolic markers, including HbA1c and insulin-based indices, would provide deeper insight into the underlying metabolic pathways. Multivariable analytical approaches accounting for potential confounders such as sleep patterns, stress levels, and occupational factors may further clarify the relationship between physical activity patterns and neurocognitive performance [27].

V. Conclusion

This study demonstrates that variations in physical activity patterns are significantly associated with differences in computerized auditory and visual reaction-time performance among adult workers. Using a PsychoPy-based experimental paradigm, sedentary individuals showed significantly prolonged auditory and visual reaction times compared with non-sedentary individuals, indicating reduced sensorimotor processing efficiency. The finding that auditory reaction time was shorter than visual reaction time in the overall sample further supports established modality-specific differences in neural processing.

In addition to delayed reaction-time responses, sedentary individuals also demonstrated significantly higher fasting blood glucose levels, suggesting a possible neuro-metabolic interaction between sedentary activity patterns, metabolic status, and functional neural performance. Although fasting blood glucose was assessed separately and not through PsychoPy, its association with reaction-time differences provides additional physiological context to the observed findings.

Overall, PsychoPy-based reaction-time assessment may serve as a practical, standardized, and non-invasive computerized approach for evaluating sensorimotor processing in occupational and health-related research settings. These findings emphasize the importance of reducing sedentary time and promoting regular physical activity to support both cognitive-motor performance and metabolic health.

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