Addressing ergonomic issues in extended reality through visual feedback for correcting users' neck and head posture

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Abstract

Extended Reality (XR), including AR and VR, is used in different areas such as entertainment, education, and healthcare, but this growing use raises concerns about user ergonomics and health. A main issue is head and neck posture, as long-term use of head-mounted displays can cause strain, discomfort, and reduced performance. We aim to investigate how different target spreads influence posture in sitting and standing positions and examine the effect of visual feedback on posture improvement. Using the headset's built-in sensors, posture is monitored through measures of forward leaning and slouching. Participants perform a target-selection task under different target spreads requiring varying amounts of visual exploration and head movement. We plan to have the body position as a between-subjects factor and target spreads as a within-subjects factor.

CCS Concepts

• **Human-centered computing → HCI design and evaluation methods**; **User studies**.

Keywords

AR/VR, Ergonomics, Head Posture

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1 Introduction

The long-term use of extended reality headsets, due to their increasing availability and widespread use in areas such as entertainment, education, and healthcare, has raised health and ergonomic concerns [2]. One important issue is user posture, which affects both comfort and performance [11]. Previous studies show that staying in non-neutral or awkward postures for a long time can cause discomfort, pain, fatigue, and reduced efficiency [9]. XR (Extended Reality) environments are usually experienced through Head-Mounted Displays (HMDs), where visual content changes in real time based on head movement, and all main system components are attached to the user's head. In this setup, the head and neck act as the main physical link between the user and the virtual environment. Consumer XR headsets usually weigh between 400 and 810 grams [1] (for example, HTC Vive: 470 g; Meta Quest 3: 515 g; and Apple Vision Pro: 809 g [12]), suggesting that XR users may face risks of neck strain and discomfort during extended headset use [3, 9]. In addition, studies show that moving away from a neutral head position increases neck muscle load, which makes head posture an important factor in ergonomic risk [7]. To reduce these risks, we propose providing HMD users with feedback while they are interacting, so that they can correct their posture and reduce the risk of strain.

Prior work has provided feedback to support ergonomic use of head-mounted displays [4], but it has primarily focused on standing interactions and limited forms of posture deviation. We extend this work by comparing *sitting* and *standing* task modes and by examining the effect of target spread on users' posture during XR interaction. By manipulating the target spreads required to locate and select targets, we investigate how visual exploration demands influence posture and whether real-time visual feedback remains effective across different interaction conditions. Our research questions are as follows:

RQ1: How does real-time visual feedback affect users' ability to maintain and correct their posture in XR?
RQ2: Does task mode (sitting vs. standing) influence posture and the effectiveness of visual feedback?
RQ3: How does the target spread influence users' posture and interaction behavior during XR tasks?
RQ4: How do users perceive the feedback in different target spreads in terms of usability, comfort, workload, and overall experience?

2 Related work

Traditional methods such as training before use or reading ergonomic guidelines are helpful, but they are not effective during real-time interaction [8]. When users are fully engaged in a XR environment, they are less aware of their posture [6]. Therefore, real-time feedback systems are important to remind users and help them correct their posture immediately [5].

Prior research in movement and perception has shown that visual feedback in virtual environments can influence how users perceive and perform movements [10].

Visual feedback plays a key role in the motion guidance systems used in XR, where it is used to inform users and support movement correction [13]. Yu et al. propose a framework that classifies visual feedback based on its type, timing, placement, and presentation, showing that color is often used to indicate problems, while directional cues are used to guide correction [13].

Although recent work [4] shows that users of XR headsets support posture feedback systems, these approaches have focused

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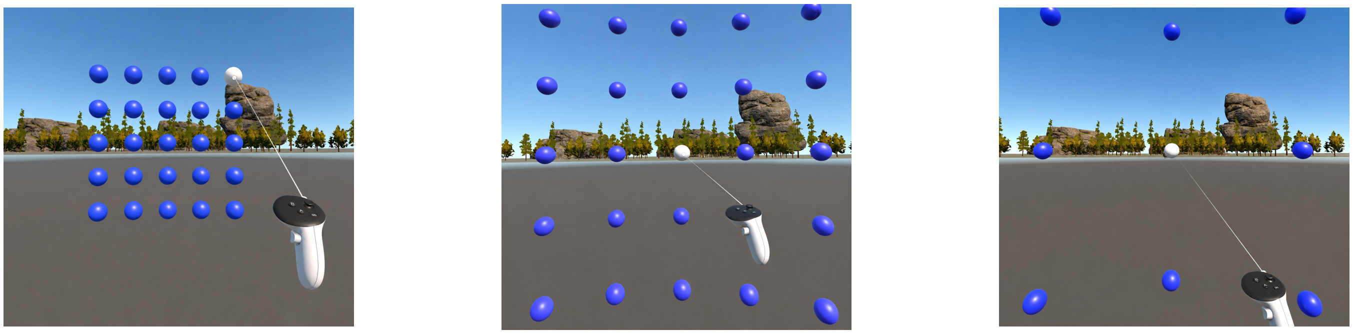

(a) 30° (b) 60° (c) 120°

Figure 1: Target spreads used to manipulate visual exploration demands. Narrow: (a), Medium: (b), and Wide: (c)

mainly on a limited set of posture deviations and have only considered standing conditions, without examining how feedback performs in other interaction postures such as sitting. In addition, only a few XR studies use the built-in sensors of head-mounted displays to detect posture. For example, Kim et al. [4] found that, among several visual designs (e.g., icons, grayscale, moving ball, and circle fill), icon-based feedback was the most preferred by users.

3 Methods

Based on prior findings, we use icon-based visual feedback to increase users' awareness of non-neutral postures. The study compares two feedback conditions: No Feedback and Feedback. In the feedback condition, users receive visual cues when forward leaning or slouching is detected.

To investigate the influence of visual exploration demands on posture, the experiment includes two body positions (Sitting and Standing) as a between-subjects factor and three target spreads (Narrow: 30°, Medium: 60°, and Wide: 120°) as a within-subjects factor. These conditions determine the spatial region in which targets are distributed around the participant (Figure 1). Wider target spreads require greater head movement and visual exploration to interact with all targets.

The study uses a target-selection task in which participants select floating targets using a controller ray pointer (Figure 2). Before each condition, a calibration procedure records the participant's baseline head orientation and height. Participants then complete the counterbalanced task under the assigned posture, feedback, and target spreads. To identify non-neutral postures, we follow the approach proposed by Kim et al. [4]. Before each condition, participants assume a comfortable, forward-facing upright posture to establish baseline head orientation and height measures. These baseline values are used as references throughout the condition. Forward leaning is detected when head orientation deviates by 10° or more from the baseline position, while slouching is detected when head height decreases by at least 2 cm relative to baseline for more than 3 seconds.

Behavioral measures include: 1) Proportion of time spent in non-neutral posture, 2) Number of posture feedback activations, 3) Time required to correct posture, 4) Magnitude of posture deviation from baseline, and 5) Task completion time. Subjective measures include usability, comfort, workload, perceived effectiveness, perceived distraction, and overall experience.

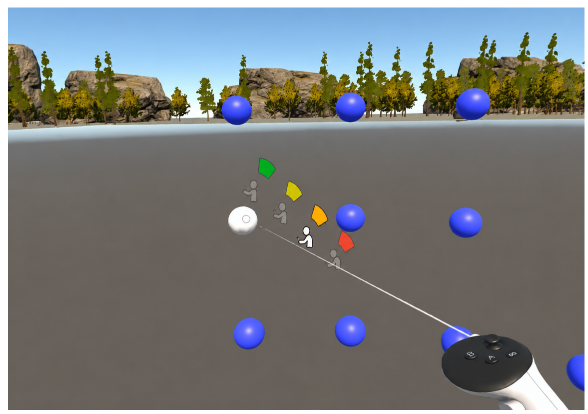

Figure 2: Target selection task and feedback

Based on our research questions, we propose the following hypotheses:

H1: Visual feedback will improve posture maintenance and correction compared to no feedback.
H2: Body position (sitting versus standing) will influence posture-related outcomes and the effectiveness of visual feedback.
H3: Wider viewing arcs will increase visual exploration demands, leading to more frequent posture feedback triggers.
H4: We expect users to report more positive subjective responses in feedback condition over no feedback.

4 Future work

Following a comparison of our initial experiment, we plan to explore posture feedback in more sedentary tasks, such as typing or desk work, where posture changes are slower but more sustained over time. Future research can also investigate multimodal feedback and personalized feedback tailored to individual user preferences and needs. Future work can extend this approach to augmented and mixed reality environments.

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