Work-a-Pose: Ergonomic Feedback and Posture Improvement Interfaces for Long-Term Sustainable Work

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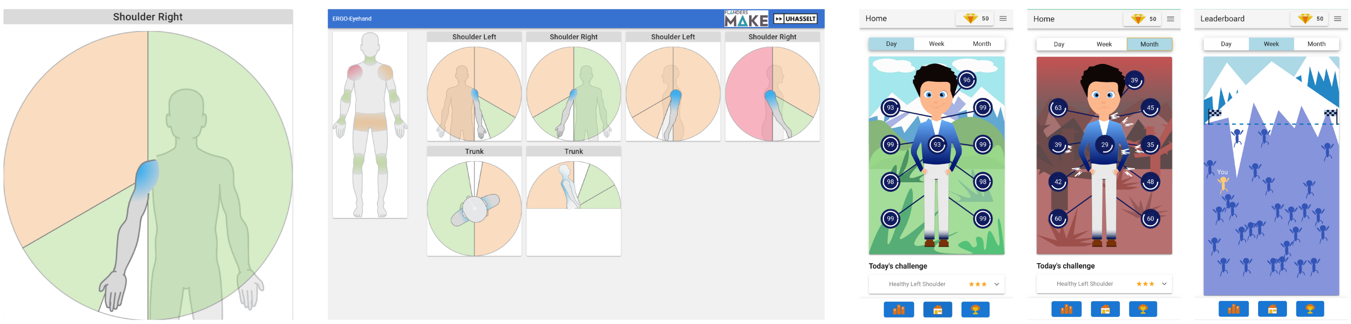

(a) (b) (c)

Figure 1: An overview of the ergonomic visualizations of *Work-a-Pose* for long-term sustainable work: ergonomic information for a single joint (a); overview of all joints, highlighting the joints at risk (b); and the motivational tool, using gamification (c).

ABSTRACT

Non-ergonomic postures and the resulting musculoskeletal disorders are key factors in worker disability and well-being. This underlines the importance of designing ergonomic work environments and educating workers in performing tasks ergonomically. We present *Work-a-Pose* to increase awareness of non-ergonomic postures and promote long-term sustainable work postures. To this end, we combine camera-based posture tracking with the automatic application of ergonomic guidelines. Glanceable visualizations highlight the worker's posture and potential ergonomic risks. A complementary, personal tool provides a more detailed overview of the worker's ergonomic score and motivates the worker to strive for a healthy work posture through simple gamification techniques.

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CCS CONCEPTS

• **Human-centered computing → Visualization systems and tools**.

KEYWORDS

posture tracking, ergonomic feedback, glanceable visualizations, gamification, sustainable work

1 INTRODUCTION

Musculoskeletal disorders (MSDs) affect the human body's movement or musculoskeletal system and are an important category of work-related injuries in many industrialized countries. Non-ergonomic postures during manual labor often cause MSDs. Those causes are usually detected after problems occur, and it is challenging to assess ergonomic risks on a per-worker and per-task basis. It is clear, however, that ergonomic postures are important in promoting health and well-being.

To perform their work ergonomically over long periods, we need to adequately inform workers on why ergonomics are important and the possible impact on their joints in the short term and on

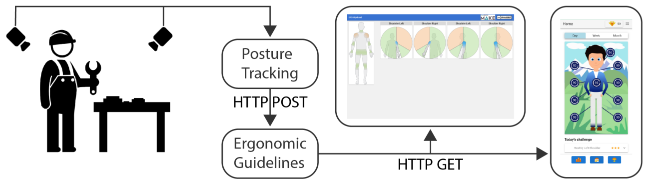

Figure 2: The main components of *Work-a-Pose*: camera-based posture tracking, analysis based on ergonomic guidelines, glanceable ergonomic feedback, and a motivational tool.

their health in the long term. Therefore, we aim to (1) make workers aware of their current posture and point out potential risks and (2) motivate workers to maintain an ergonomic posture during manual labor. Our approach uses carefully designed glyphs that inform workers about their posture with a simple glance. In addition, a motivational tool encourages workers to improve their posture over time. *Work-a-Pose* aids in this last aspect by showing the current posture and ergonomic score, as well as offering more detailed insights into that ergonomic score.

2 SYSTEM OVERVIEW

Work-a-Pose consists of four main components, as illustrated in figure 2. The camera-based *posture tracking* continuously provides information about the posture of the worker. This information is stored and analyzed based on a set of *ergonomic guidelines*, which were created in collaboration with ergonomic domain experts. We specifically focus on posture information collected throughout the entire working day to capitalize on the benefit that our posture tracking can monitor the worker continuously, in contrast to an ergonomic expert who can only assess the situation sporadically. The *glanceable ergonomic feedback* informs the worker about the ergonomic information in real-time, while the *motivational user interface* relies on simple gamification techniques to keep the worker motivated to use sustainable postures over longer periods of time.

2.1 Posture Tracking and Ergonomic Guidelines

The posture tracking uses depth- or RGB-cameras to avoid being restrictive for the worker, in contrast to tracking approaches requiring markers on the body. Systems such as OpenPose [2] can be used to track the worker's posture. *Work-a-Pose* currently requires posture data in the Captiv format[1], but can be extended to support any posture format.

To analyze the input of the posture tracking, *Work-a-Pose* uses a set of ergonomic guidelines based on the work of Peereboom [8]. The worker's posture is subdivided into joints (e.g., the trunk, table 1). For each joint, zones represent a certain range of movement (e.g., flexion of the trunk between 20° and 60°), with thresholds for the amount of time spent in a zone (e.g. 33 minutes of flexion between 20° and 60°). The first zone is the default zone, which is a range that is 'safe' during an eight-hour work shift. The other zones have three thresholds: green, orange, and red. Once the threshold of the green zone is crossed, the zone turns orange and then red.

[1]Captiv Tracking Suit

Table 1: A segment of the ergonomic guidelines used in *Work-a-Pose*, showing zones and thresholds for the trunk.

Zone	Angles	Posture	Green	Orange	Red
1	0-20°	Flexion	8:00	-	-
	0-10°	Rotation	8:00	-	-
	0-10°	Lateral Flexion	8:00	-	-
2	20-60°	Flexion	<0:33	0:34-1:36	>1:36
	>10°	Rotation	<0:33	0:34-1:36	>1:36
	>10°	Lateral Flexion	<0:33	0:34-1:36	>1:36
3	>60°	Flexion	<0:09	0:09-1:36	>1:36
	<0°	Extension	<0:09	0:09-1:36	>1:36

In the orange zone, caution is advised. In the red zone, the worker should stop that movement due to the increased risk of injury.

The amount of time spent in a zone only considers a static posture kept for at least four seconds, as defined by the European norm EN1005-4 [1]. Additional ergonomic guidelines can be incorporated into *Work-a-Pose*, for instance, with regard to the number of repetitions within a certain time span, but this should be decided in collaboration with ergonomic domain experts, taking into account the specific scenario in which *Work-a-Pose* is to be used.

2.2 Glanceable Ergonomic Feedback

As there is no way to reduce the time spent in a zone, it is important that the worker is aware of the zones and their thresholds and can actively avoid red zones. We designed visualizations to provide real-time feedback to the worker at a glance during work activities [9]. To this end, *Work-a-Pose* makes use of *glanceable glyphs*: easy-to-read status visualizations, such as the glyph for a single joint in figure 1-a. Figure 1-b shows how such glyphs can be aggregated and combined with an overall posture representation that presents an overview to the worker.

Figure 3 shows an annotated example of a glyph: all zones are green at the start of the work shift, but are continuously updated during work activities according to the posture information that is captured by the tracking system. When a threshold of a zone is crossed, the color is updated. Getting a quick update about the zones in danger by glancing at the visualization allows the worker to take appropriate actions: if a zone turns orange, the worker knows that caution is advised.

For the design of our glyphs, we applied design heuristics that were identified for ambient displays by Mankoff et al. [6] and usability heuristics of Nielsen [7], including 'sufficient information design', 'consistent and intuitive mapping', 'visibility of state', 'peripherality of display', 'error prevention' and 'flexibility and efficiency of use'. Thanks to the use of color changes, the glanceable glyphs have the potential to be used as an ambient display, not requiring the full visual attention of the worker [5].

2.3 Motivational Tool and Gamification

The glanceable glyphs are designed to be used during work activities. To motivate workers to use sustainable postures over longer

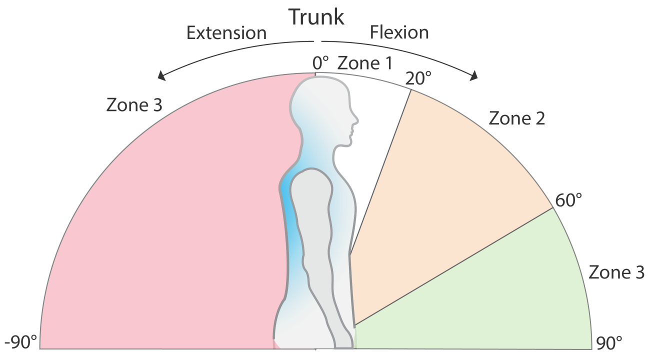

Figure 3: Annotated visualization to show the different zones and corresponding angles of the trunk.

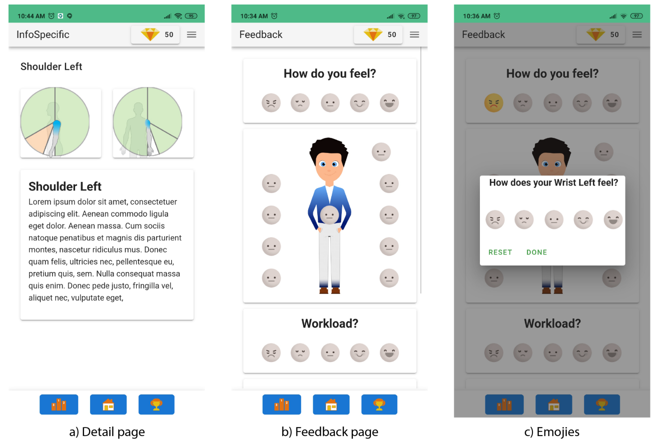

Figure 4: The 'details' page of the motivational tool shows the corresponding visualizations for that joint, and the 'feedback' page allows workers to provide additional input on their well-being and workload.

periods, *Work-a-Pose* also includes a motivational tool that workers can use during breaks or before or after work. It serves as a complementary feedback mechanism that informs workers on the effect of complying with the real-time feedback of the glyphs. The motivational tool uses gamification techniques used in many games as incentives to optimize performance and adherence [3, 4]:

- A *leaderboard* ranks the worker based on a daily 'ergonomic quality' score, using the worker's posture metrics for an entire day. It stimulates anonymous competition, as the worker's score is visualized compared to other workers doing similar work (figure 1-c, right-most picture).
- Participating in challenges and reaching the associated goals represent *progress*, and thus improvement, for the worker. Challenges can be general, such as improving one's position on the leaderboard or focusing on improving the posture for a subset of joints that previously had a low score.
- As a *reward* for progress and adherence, the worker can unlock achievements (e.g., unlock a badge for spending three weeks in a row in the top three on the leaderboard). Progress can also earn the worker virtual currency that workers can spend in a *Work-a-Pose* store, which can be filled with items according to the human resources and company policy.
- A *personal avatar* reflects the overall ergonomic score of the worker. A good ergonomic score results in a happy avatar. A bad ergonomic score in an avatar in pain, with indicators for the joints with a low score and might feel 'sore' (figure 1-c). This provides a subtle yet effective incentive to pay attention to the feedback offered by the glyphs.

The motivational tool also includes more detailed insights into the ergonomic score (figure 4-a) and a feedback page that allows workers to provide input on their well-being and workload (figure 4-b). Capturing their input is done with a scale of five emojis, mapped to a one-to-five rating (figure 4-c). In its current status, this feedback page is not yet automatically processed. Still, we plan to use this as a self-reporting tool to validate and personalize the real-time feedback and assess whether workers require additional support.

3 CONCLUSION

Being able to perform tasks ergonomically plays a vital role in well-being at work, but it requires a substantial effort from both the company and the workers. The company must provide the means, equipment, time, and training to create an ergonomic work environment. On the other hand, the workers are responsible for using the equipment correctly and paying attention to proper ergonomic movements to perform tasks. To help workers with that responsibility, we present *Work-a-Pose*. It provides workers with insights into their posture and ergonomic score and tries to motivate them to keep taking ergonomics into consideration through gamification techniques. Further work is required to evaluate the visualizations with workers in a work environment and monitor the actual long-term impact on health and well-being.

Work-a-Pose comes with several challenges and opportunities for improvements. Camera-based tracking, for instance, can be unreliable due to obstructions of the field of view throughout a working day. Furthermore, proper privacy-related guidelines are essential. With regard to the ergonomic feedback, the current visualizations only highlight the issues but do not provide solutions. When a zone turns orange, it is up to the workers to figure out how not to end up in a red zone, which might not be easy. It might not even be feasible in the short term, as it may require far-reaching or structural changes. Without *Work-a-Pose*, however, the workers would not have any information on potential issues and would simply continue using non-ergonomic postures. Therefore, we believe that *Work-a-Pose* is an important step towards creating awareness and increasing the long-term health and well-being of workers.

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