University of Stuttgart
Visualization Research Center (VISUS)

Created with Bing Copilot Designer [1]

Sitting Posture Recognition and Feedback: A Literature Review

Christian Krauter, Katrin Angerbauer, Aimée Sousa Calepso, Alexander Achberger, Sven Mayer, Michael Sedlmair

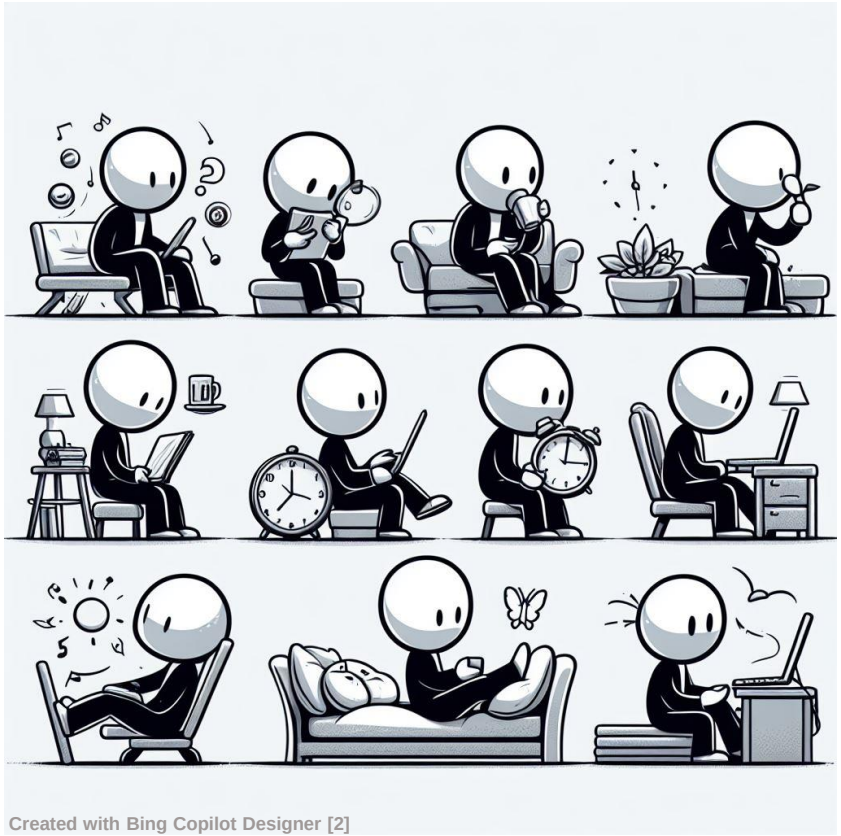





LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN
imprs-is
SFB-TRR 161 Quantitative Methods for Visual Computing
SimTech Cluster of Excellence

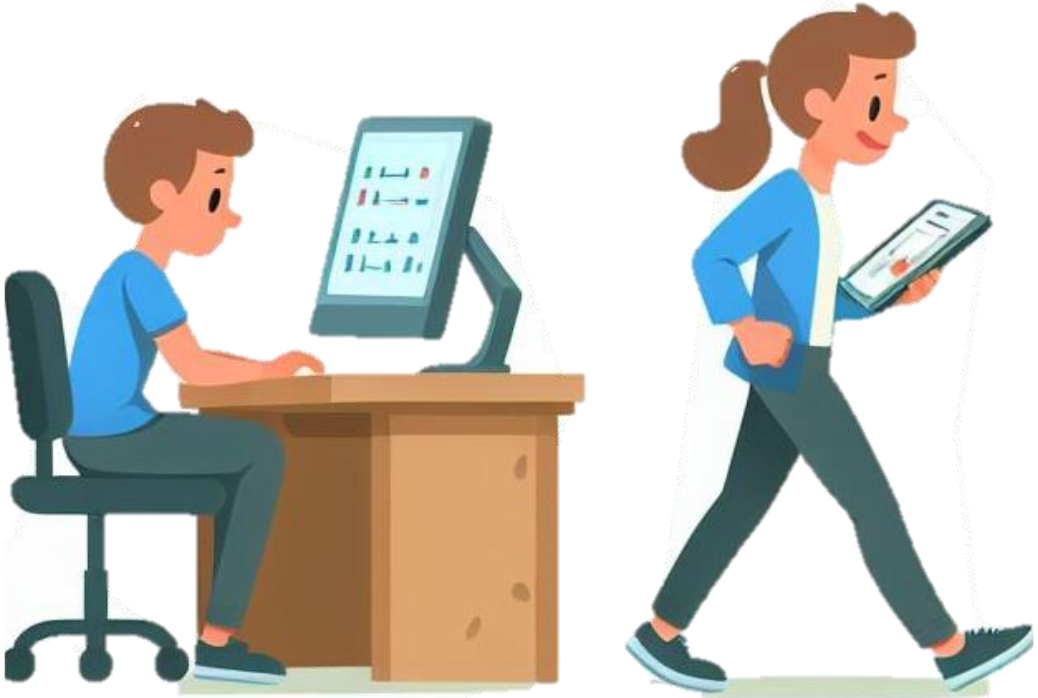
Sitting and Health

- 5 to 12.5 hours per day [3, 4, 5, 6]
- Adverse effects on health [7, 8, 9, 10, 11, 12]



Created with Bing Copilot Designer [2]

The Solution

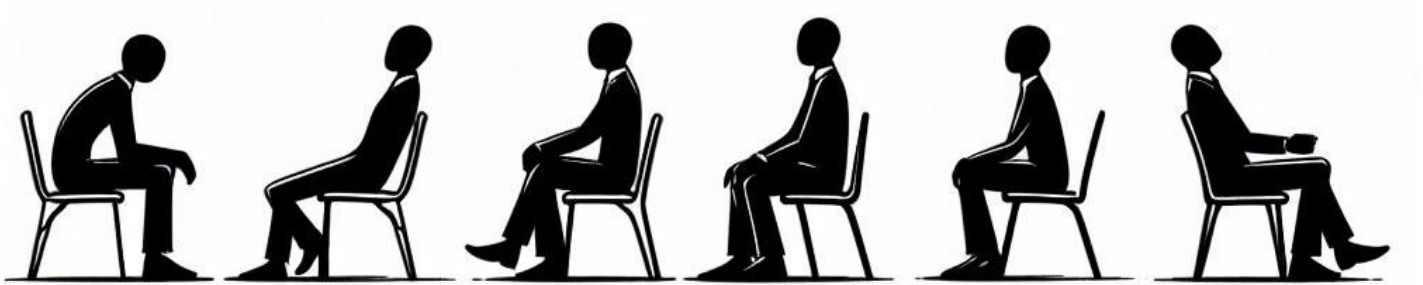


Created with Bing Copilot Designer [13]

The Solution…?

- Designed for sitting
- Standing is tiring
- Not everyone is able to stand

Created with Bing Copilot Designer [14]

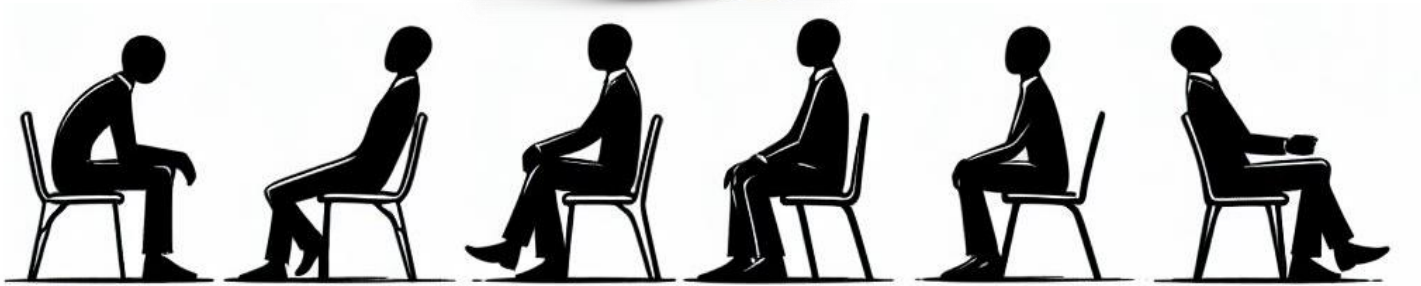


Created with Bing Copilot Designer [15]

“the best posture is the next posture“ – Biddle et al. IJERPH ’19 [16]

How To Support Posture Changes

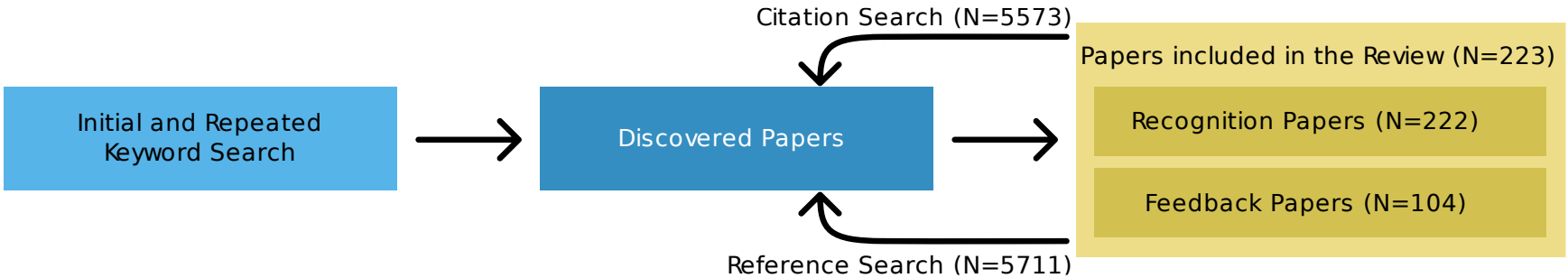
1. Recognize posture
2. Give feedback

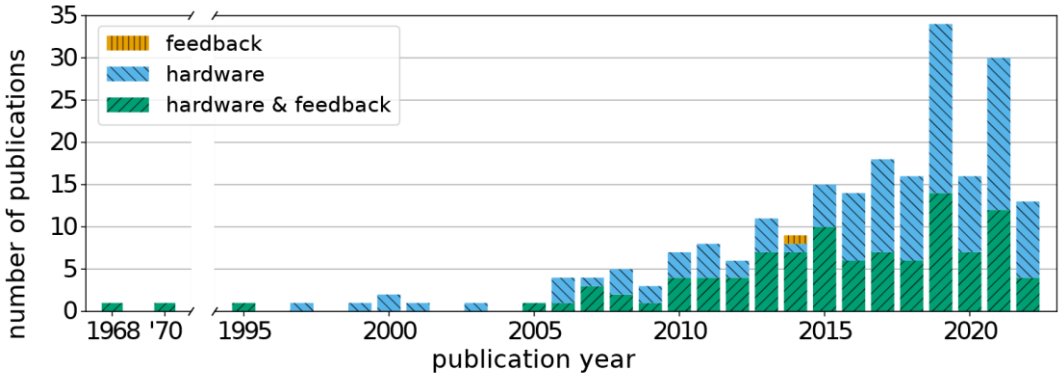


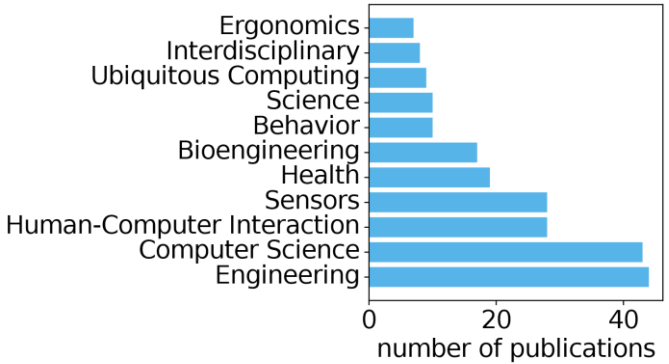
Created with Bing Copilot Designer [15]

“the best posture is the next posture“ – Biddle et al. IJERPH ’19 [16]

Literature Review – Recognition & Feedback







Sitting Posture Recognition

222 papers

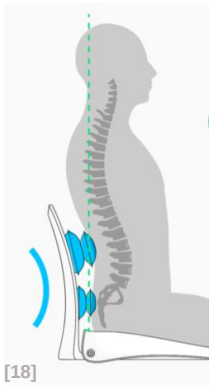
- Deformation Sensors (8)
- Distance Sensors (9)
- Combinations (25)
- Vision-based (31)
- Motion Sensors (36)
- Other (17)
- **Pressure Sensors (97)**

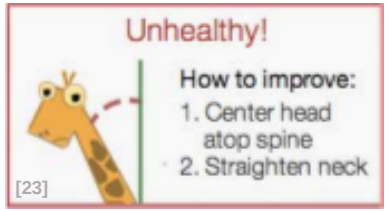
[17]

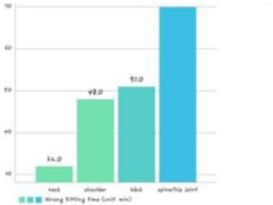
Sitting Posture Feedback

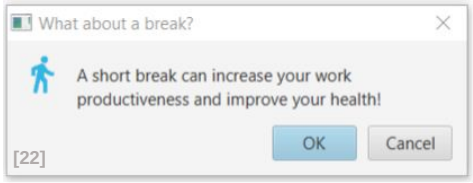
104 papers

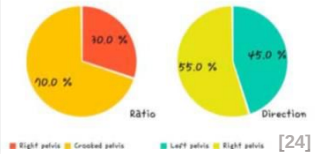
- Active (14)
- Sound (32)
- Vibration (33)
- **Visual (69)**
  - Images and Videos (8)
  - Physical objects (16)
  - Text messages (19)
  - Sketches (26)
  - Charts (32)
  - Other (10)
  - Real-time (66) vs. Summarized (24)









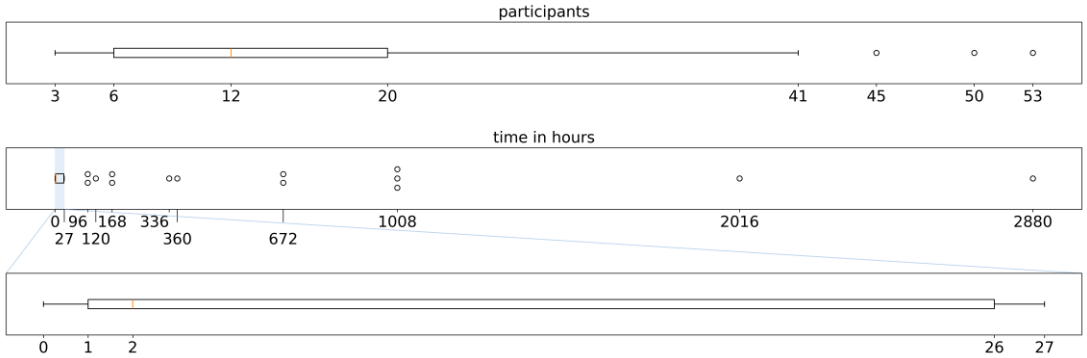


Evaluation of Sitting Posture Feedback

64 User Studies

- **37 lab**, **25 in-situ**, 1 online, 1 VR
- ∅ 15 Participants, CHI ∅ 12 (Caine et al. CHI'16 [25])
- Most studied **short sessions (40)**
- Main study task: **PC work (51)**
- Studied measures
  - Task performance (8)
  - Open feedback (10)
  - Comfort (10)
  - Usability/ UX (25)
  - **Posture behavior (54)**

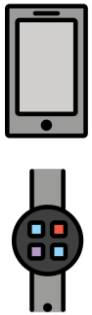
- Results
  - **Positive to mixed effects** of feedback on these measures
  - **Advantage of combinations**

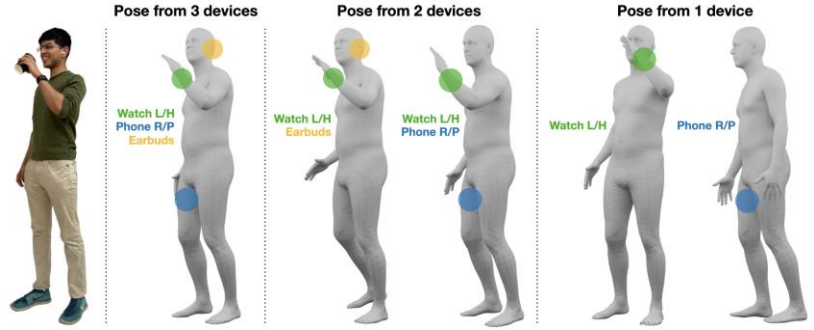


Recommendations For Recognition

- Hardware depends on **task and user**
  - Mobility? – Wearable sensors, pressure sensor cushion
- **Simple setup can be sufficient**
  - More granular postures? – More sensors, vision-based system
- Integrate into **existing devices** to reach as many people as possible

[17]

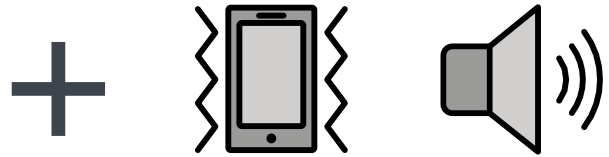


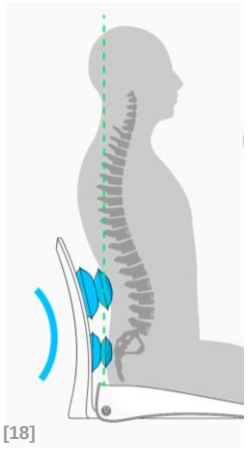


IMUPoser, CHI'23, Mollyn et al. [27]

Recommendations For Feedback

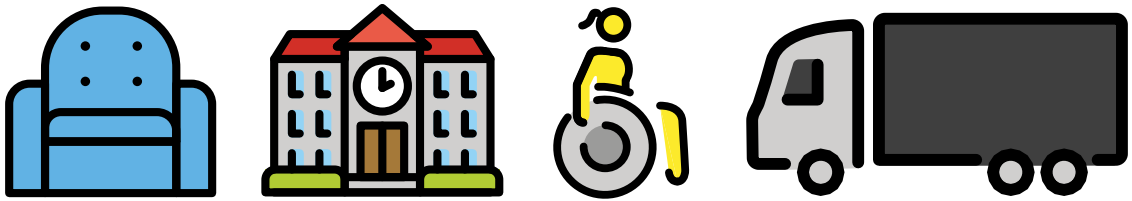
- **Use visual feedback for prototyping**
- Build **modular and customizable** systems that adapt to the users





Recommendations For Evaluating Feedback

- Better **comparability** needed to study long-term effects
- Study **different settings**
- **Cross- and inter-disciplinary research**



University of Stuttgart
Visualization Research Center (VISUS)

Sitting Posture Recognition and Feedback: A Literature Review

- **Scanned ~11k** papers from 11 research fields
- Cover **223 publications** from **1968-2022**
- **Categorized** recognition and feedback approaches
- Analyzed **64 user studies**
- Offer **recommendations for research and development**
- **Paper, tables, slides** and **more** available

chriskrauter.de






VISUS LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN imprs-is SFB-TRR 161 Quantitative Methods for Visual Computing SimTech Cluster of Excellence

References

[1] Bing Copilot Designer. DALL-E 3, 7.3.24, prompt: “A stick figure sitting on a chair. A sensor is attached on the stick figures back. The perspective is from behind. A screen is floating in front of the stick figure. On the screen, there is an image of a sitting stick figure with a pie chart. a tiny camera is attached to the top of this screen. make the background completely white”

[2] Bing Copilot Designer. DALL-E 3, 15.03.24, prompt: „A stick figure sitting on different objects throughout the day, from a side perspective, with a completely white background.“

[3] Bauman, A. et al. 2011. The Descriptive Epidemiology of Sitting. American Journal of Preventive Medicine. 41, 2, 228–235. 10.1016/j.amepre.2011.05.003.

[4] Wallmann-Sperlich, B. et al. 2013. Sitting time in Germany: an analysis of socio-demographic and environmental correlates. BMC Public Health. 13, 1, 196. 10.1186/1471-2458-13-196.

[5] Mclaughlin, M. et al. 2020. Worldwide surveillance of self-reported sitting time: a scoping review. Int. Journal of Behavioral Nutrition and Physical Activity. 17, 1, 111. 10.1186/s12966-020-01008-4.

[6] Kazi, A. et al. 2014. A survey of sitting time among UK employees. Occupational Medicine. 64, 7, 497–502. 10.1093/occmed/kqu099.

[7] Dunstan, D.W. et al. 2012. Too much sitting – A health hazard. Diabetes Research and Clinical Practice. 97, 3, 368–376. 10.1016/j.diabres.2012.05.020.

[8] Waongenngarm, P. et al. 2015. Perceived body discomfort and trunk muscle activity in three prolonged sitting postures. Journal of Physical Therapy Science. 27, 7, 2183–2187. 10.1589/jpts.27.2183.

[9] Rezende, L.F.M. et al. 2016. All-cause mortality attributable to sitting time. American Journal of Preventive Medicine. 51, 2, 253–263. 10.1016/j.amepre.2016.01.022.

[10] Daneshmandi, H. et al. 2017. Adverse effects of prolonged sitting behavior on the general health of office workers. Journal of Lifestyle Medicine. 7, 2, 69–75. 10.15280/jlm.2017.7.2.69.

[11] Albarrati, A. et al. 2018. Effect of Upright and Slouched Sitting Postures on the Respiratory Muscle Strength in Healthy Young Males. BioMed Research Int., 1–5. 10.1155/2018/3058970.

[12] Stamatakis, E. et al. 2019. Sitting time, physical activity, and risk of mortality in adults. Journal of the American College of Cardiology. 73, 16, 2062–2072. 10.1016/j.jacc.2019.02.031.

[13] Bing Copilot Designer. DALL-E 3, 15.03.24, prompt: „A young female cartoon character in different situations: driving a cabrio, driving a truck, sitting in a wheelchair, sitting at the cash register, and other typical sitting scenarios, from a side perspective, with a completely white background.“

[14] Bing Copilot Designer. DALL-E 3, 15.03.24, prompt: „A cartoon character in different activities like walking, working at a standing desk, jogging, etc., from a side perspective, with a completely white background.“

[15] Bing Copilot Designer. DALL-E 3, 15.03.24, prompt: „Stick figures in various sitting postures for chairs, from a side perspective, with a completely white background.“

[16] Biddle et al. 2019. Controversies in the Science of Sedentary Behaviour and Health: Insights, Perspectives and Future directions from the 2018 Queensland Sedentary Behaviour Think Tank. IJERPH, 16, 23, 4762. 10.3390/ijerph16234762.

[17] Hong, J.-K. et al. 2015. BeuPo: a digital plant that you can raise and customize with your current posture. Proc. UbiComp, 1015–1020. 10.1145/2800835.2800953

[18] Shen, Z. et al. 2021. SeatPlus: A smart health chair supporting active sitting posture correction. Proc. HCII, 531–547. 10.1007/978-3-030-78224-5_37

[19] https://openmoji.org/

[20] Speir, J. 2015. PostureChair: A real-time, as-needed feedback system for improving the sitting posture of office workers. Carleton University. https://curve.carleton.ca/297e4d41-ae13-4740-bccb-5d21ca40265d

[21] Hong, J. et al. 2015. Better Posture Awareness through Flower-Shaped Ambient Avatar. Proc. TEI, 337–340. 10.1145/2677199.2680575

[22] Wang, Y. and Reiterer, H. 2019. The point-of-choice prompt or the always-on progress bar? Proc. CHI EA, 1–6. 10.1145/3290607.3313050

[23] Khurana, R. et al. 2014. NeckGraffe. Proc. CHI EA, 227–232. 10.1145/2559206.2580936

[24] Cho, H. et al. 2019. Sitting posture prediction and correction system using arduino-based chair and deep learning model. Proc. SOCA, 98–102. 10.1109/soca.2019.00022

[25] Caine, K. 2016. Local standards for sample size at CHI. Proc. CHI, 981–992. 10.1145/2858036.2858498

[26] Mollyn, V. et al. 2023. IMUPoser: Full-body pose estimation using IMUs in phones, watches, and earbuds. Proc. CHI. 10.1145/3544548.3581392