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Investigating Ergonomic Heuristic Paradigms Quantitatively with Cricket Muscle Sensors

Overview: In this paper we establish two points.

1) It's safer to keep keyboards close to the body during typing at a computer workstation *(something you already knew)*

2) The use of arm-rests is not recommended during typing at a computer workstation *(something you may not have known)*

Introduction:

Traditional ergonomic evaluation techniques are standardized through guidelines developed by OSHA and other organizations. The roots of these standards are based in principles which are both intuitive and also frequently derived heuristically and empirically - that is to say based on decades of observations of postures, workstation configurations, body positions, and outcomes (injury states, workers comp claims, etc).

Somaxis Inc is a sensor manufacturer that specializes in wearable sensors including the Cricket muscle / posture sensor (sEMG + gyroscope) designed as a tool for professional ergonomists. Using Cricket, ergonomists can quantitatively validate and customize ergonomic evaluations and adjustments. They can also challenge preconceptions about factors which affect outcomes and which often do not get addressed through standard environmental screenings. These factors involve user behavior and use of the body in a correct or incorrect manner with respect to the use of muscles.

Consider the following:

- A well-optimized environment minimizes risk of injury to an individual working at a computer
- However, you can put someone in the perfect environment and if they use their body incorrectly, they can still develop muscle pain and injuries.
- Baseline muscle loading, in particular in the Upper Trapezius functional group, is a key variable to monitor which is associated with common work-related pain.
- Upper Trapezius muscles are not required for Typing, Mousing, or other common work-related tasks.
- A muscle at rest always has baseline tension around 2 - 3 uV, regardless of age, gender, race, or BMI. It is therefore quite easy to quantify excessive muscle loading, in particular when answering questions in the format: “Which is better: doing a task this way or doing it that way?”

Further, by using muscle sensors as a vehicle for quantitatively enhancing ergonomic evaluations, the professional ergonomist may determine to what extent various adjustments are beneficial for a specific individual, given the large degree of individual variation in physiology and body types. Muscle sensors can also be used as training tools for individuals who demonstrate high baseline muscle tension. That is to say, high muscle loading levels are not indicative of a disease state. Baseline muscle tension as a biomarker indicates a risk factor, not a standalone diagnostic variable. This is good. Baseline muscle tension is trainable, and regardless of the individual, risk of muscle pain and soreness is reduced when baseline muscle tension is minimized. So, sensors can be used for objective and scientific ergonomic assessments, automatic report generation, quantifying the degree of improvement pre- and post-adjustments, determining who may have behavioral risk factors, and in giving those individuals active training tools to reduce those risk factors.

We are looking at two sets of variables here:

1) What is the effect, if any, on keyboard position being far from the body as opposed to near the body? Traditional recommendations dictate that one should type with the elbows around 90 degrees and the keyboard close to the body. But when the keyboard is extended, what is the effect on muscle loading on the Upper Trapezius muscle group as compared with the recommended placement? Does it make a difference? And if so, how much?

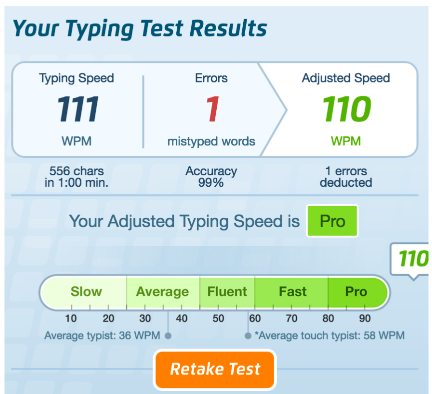
2) What is the effect, if any, on typing while resting arms on armrests as opposed to typing without using armrests? Traditional recommendations allow for use of armrests provided

that the elbows stay at 90 degrees and the armrests are adjusted to the correct height for the natural placement of the elbows.

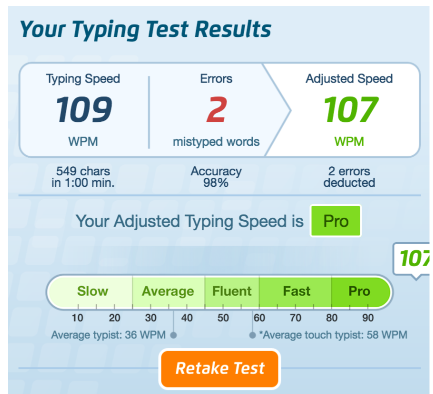
Methods:

For these tests, a speed typing test was conducted via typingtest.com. Performance characteristics were measured via the website's methods are comparable with and without arm-rests as well as typing with the keyboard far from the body as well as close to the body:

With arm-rests



Without arm-rests



Further, as mentioned above, the Cricket wireless muscle sensor was used for measurements. The data is 16-bit, sampled at 1000 s/s, filtered from 70 - 200 Hz to eliminate cardiac artifact, and further processed to produce "Scores" using patented algorithms to quantify baseline muscle loading. Crickets are designed to "float" above the skin during movements and skin-stretch to minimize movement artifact, making them ideally suited to real-world applications like ergonomic assessments in the field.

"It may surprise you to learn that the use of armrests biases many people towards injury states. Do them a favor - don't allow the use of arm-rests."

In the top row, we see a photo of the use of arm-rests during typing tasks, and a photo without the use of arm-rests (the arm-rests are rotated backwards behind the user and are not being used even though they are still visible). Note that the difference in terms of posture / body position is quite subtle and not obvious to the naked eye. In both cases the elbow angle is roughly 90 degrees and in neither case are the shoulders visibly elevated. Rather during the use of arm-rests, there is a tendency to "brace" against them during activities like typing.

Below, in the second row, we see a photo of improper extension of the arms with a poorly positioned keyboard far in front of the body, and next to it a photo of a keyboard that is placed close to the body so that the elbows are bent at 90 degrees.

Results

In the following Individual Reports, we will ultimately see the following:

1) **Typing with armrests results in baseline muscle tension of 6.5 as compared with typing without armrests which results in baseline muscle tension of 3.4.** Note that baseline tension is not the same as average work done by the muscles, which is much higher. The question is, "Which is preferable?" Since we know that a relaxed muscle rests

between 2 - 3 microvolts, baseline tension of 6.5 (and average loading that is closer to 8.5) does represent elevated tension levels double the resting state. It may surprise you to learn that the use of arm-rests biases many people towards injury states. The data here demonstrates a risk factor not presently addressed by the heuristic paradigms. OSHA guidelines do not suggest that arm-rests are a risk factor. However, you should do your customers a favor - don't allow them use of arm-rests. They don't help, and often bias health outcomes negatively. However, not everyone is affected equally by the use of arm-rests. Profiling individuals in their native environment using muscle tension sensors, one can quantitatively determine if this specific risk-factor is significant for the individual being analyzed.

2) **Typing with your keyboard far from your body results in baseline tension of 11.6. Typing with your keyboard close to your body (without armrests) results in baseline muscle tension of 3.5.** This is even more dramatic of a risk factor than typing with arm-rests. This risk factor also coincides with common knowledge regarding best practices for ergonomic assessments and OSHA guidelines. Keeping your keyboard close to your body when typing is known to be the best way to type. The data confirms the heuristic paradigm.

Detailed Individual Reports and Data

Summary Of Results

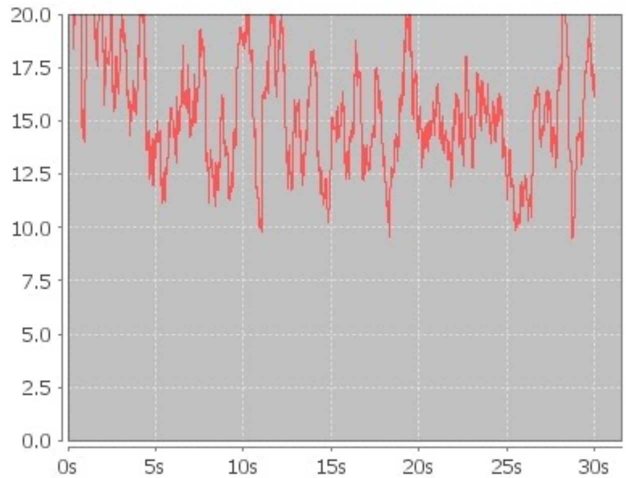
Number Of Activities	2
Activity 1 name	Typing with keyboard far from body
Activity 2 name	Typing with keyboard near body
Number Of Muscles	2
Muscle 1 Name	Left Upper Trapezius
Muscle 2 Name	Right Upper Trapezius
Activity Weight	1:0.5 ; 2:0.5
Muscle Weight	1:0.5 ; 2:0.5
Epoch Weight	H:0.01 ; L:0.95 ; A:0.04
Filter	EMG:70-200 ; SMOOTHING:0.5
Scores	Typing with keyboard far from body : 11.6
	Typing with keyboard near body : 3.5
	Left Upper Trapezius : 7.2

	Typing with keyboard far from body	Typing with keyboard near body	
LUT	11.2	3.1	7.2
RUT	11.9	3.8	7.9
	11.6	3.5	

Data Detail

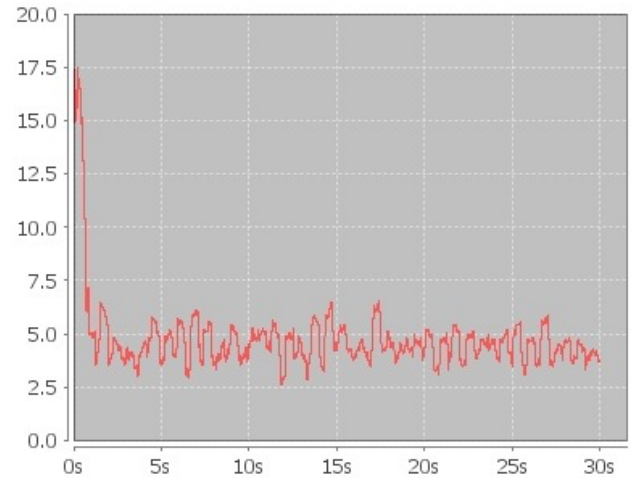
LUT

Typing with keyboard far from body



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 29.9 L: 13.6 A: 19.4 S: 14	H: 19.3 L: 11 A: 14.3 S: 11.2	H: 21 L: 9.8 A: 16 S: 10.1	H: 20.3 L: 9.6 A: 14.6 S: 9.9	H: 18 L: 11.9 A: 15 S: 12.1	H: 21.5 L: 9.5 A: 14.4 S: 9.8

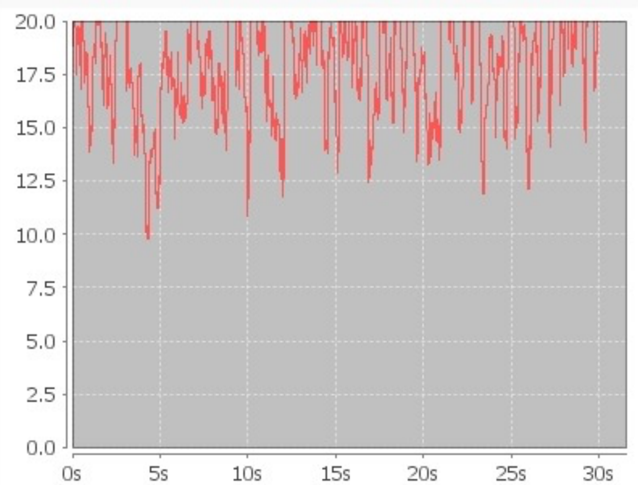
Typing with keyboard near body



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 17.5 L: 3 A: 6 S: 3.3	H: 6.1 L: 2.9 A: 4.6 S: 3	H: 6.5 L: 2.6 A: 4.7 S: 2.7	H: 6.5 L: 3.1 A: 4.4 S: 3.1	H: 5.7 L: 3.1 A: 4.5 S: 3.1	H: 5.9 L: 3.3 A: 4.2 S: 3.4

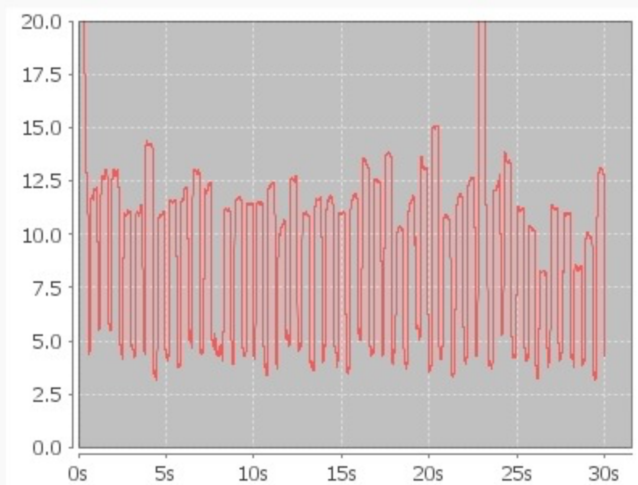
RUT

Typing with keyboard far from body



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 37.1 L: 9.8 A: 18.1 S: 10.4	H: 28.6 L: 10.8 A: 18.3 S: 11.3	H: 26.3 L: 11.8 A: 18.5 S: 12.2	H: 23.5 L: 12.5 A: 18.4 S: 12.8	H: 24.9 L: 11.9 A: 18.2 S: 12.3	H: 24.7 L: 12.1 A: 19.5 S: 12.5

Typing with keyboard near body



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 24 L: 3.2 A: 10.6 S: 3.7	H: 13.1 L: 3.8 A: 8.8 S: 4	H: 12.7 L: 3.4 A: 8.8 S: 3.7	H: 13.8 L: 3.5 A: 9.2 S: 3.8	H: 47.5 L: 3.3 A: 12.3 S: 4.1	H: 13.1 L: 3.2 A: 8.1 S: 3.5

Summary Of Results

Number Of Activities	2
Activity 1 name	Typing with Armests
Activity 2 name	Typing without Armrests
Number Of Muscles	2
Muscle 1 Name	Left Upper Trapezius
Muscle 2 Name	Right Upper Trapezius
Activity Weight	1:0.5 ; 2:0.5
Muscle Weight	1:0.5 ; 2:0.5
Epoch Weight	H:0.01 ; L:0.95 ; A:0.04
Filter	EMG:70-200 ; SMOOTHING:0.5
Scores	Typing With Armrests : 6.5
	Typing Without Armrests : 3.4
	Left Upper Trapezius : 4.7
	Left Upper Trapezius : 5.3

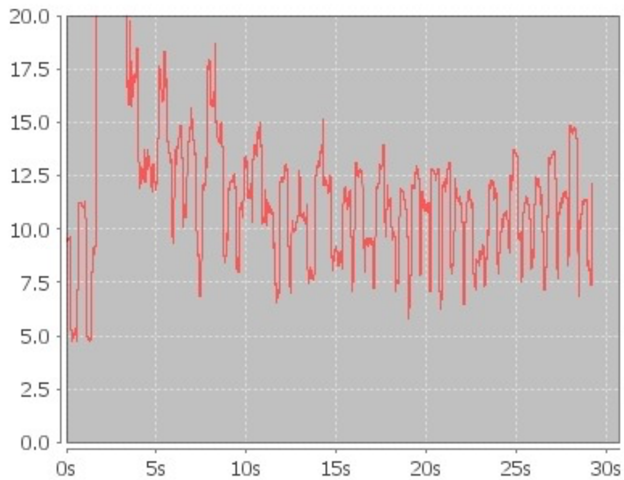
	Typing with armrests	Typing without armrests	
LUT	6.4	3	4.7
RUT	6.6	3.9	5.3
	6.5	3.4	

Data Detail

	Typing with armrests	Typing without armrests

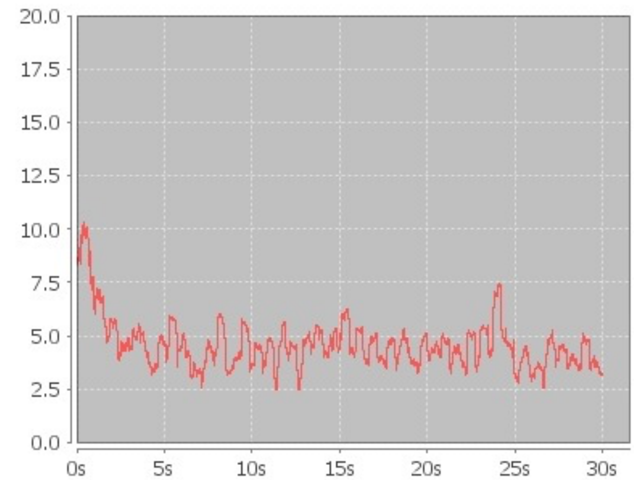
LUT

Typing with armrests



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 47.5 L: 6 A: 15.5 S: 6.8	H: 13.6 L: 6.2 A: 9.8 S: 6.4	H: 9.3 L: 6 A: 7.8 S: 6.1	H: 10.6 L: 6.2 A: 8.3 S: 6.3	H: 11.7 L: 6.1 A: 8.1 S: 6.2	H: 10.2 L: 6.3 A: 7.9 S: 6.4

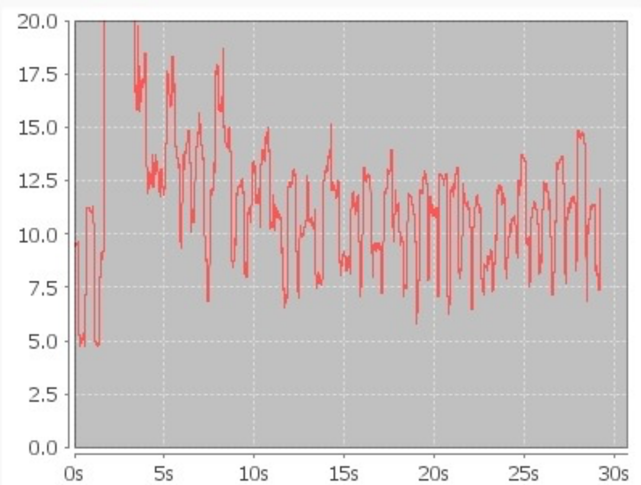
Typing without armrests



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 10.3 L: 3.1 A: 5.7 S: 3.3	H: 6 L: 2.6 A: 4.3 S: 2.7	H: 6.3 L: 2.5 A: 4.6 S: 2.6	H: 5.8 L: 3.2 A: 4.4 S: 3.3	H: 7.5 L: 3.2 A: 4.7 S: 3.3	H: 5.3 L: 2.5 A: 3.9 S: 2.6

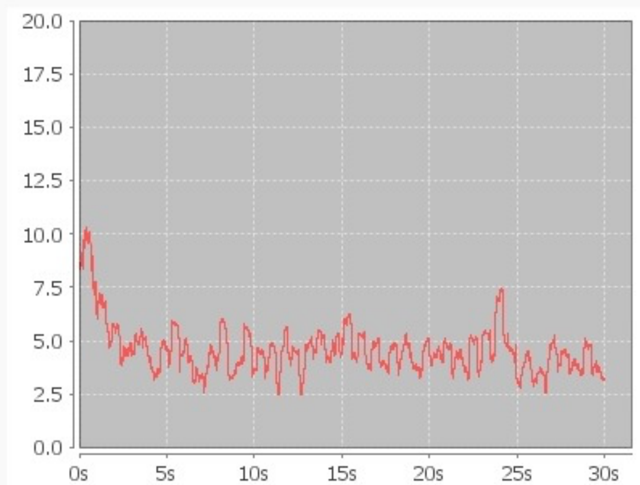
RUT

Typing with armrests



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 74.5 L: 4.7 A: 22.7 S: 6.1	H: 18.7 L: 6.9 A: 12.6 S: 7.2	H: 15.1 L: 6.6 A: 10.4 S: 6.8	H: 14 L: 5.8 A: 10.6 S: 6.1	H: 13.1 L: 6.3 A: 10.3 S: 6.5	H: 14.9 L: 6.9 A: 11.2 S: 7.1

Typing without armrests



0–5s	5–10s	10–15s	15–20s	20–25s	25–30s
H: 17.3 L: 3.8 A: 9.2 S: 4.2	H: 11.7 L: 3.3 A: 8.1 S: 3.6	H: 13.9 L: 3.5 A: 9.4 S: 3.9	H: 11.8 L: 3.7 A: 7.6 S: 3.9	H: 14.4 L: 3.5 A: 9.2 S: 3.9	H: 15 L: 3.5 A: 8.7 S: 3.8

Discussion

Of note is that some individuals perform very differently from others. Some will have much smaller differences as a result of varying the factors shown in these examples (arm-rest usage, keyboard location). Some will have much greater differences. Ultimately this fact highlights the need for implementation of sensors into ergonomic assessments even more, so that ergonomists can figure out which these heuristics actually apply to the individual in front of them being assessed. The ergonomist is empowered to determine:

* Is the individual the kind of person who is extremely sensitive to environmental configurations or the kind of person who isn't?
* Which "common knowledge" best practices are effective with this individual? Which aren't?
* What factors may trigger this individual which are not part of the "common knowledge" of best practices?
* What muscle groups are highest risk for a specific individual?
* What kinds of activities are highest risk for a specific individual?
* Is it a person who tends to use their bodies incorrectly even in the perfect environmental configuration, or are ergonomic adjustments sufficient to minimize risk for them?
* Does an individual require feedback / monitoring / training, even after their ergonomic evaluation / adjustments are completed?