Smart wear measurements illustrate the load of cleaning work

The measurements were carried out in the project
ErgoClean, Cleaning ergonomics – to prevent occupational diseases and accidents

CLEANING ERGONOMICS

Introduction

Cleaning is considered a medium-heavy job. What does that mean and where does the load fall? The ErgoClean project set out to find the answer using smart wear measurements.

The measurements used smart clothing and technology from the Finnish company Myontec. Motion sensors in the smart shirt and shorts were used to measure the load on the arms, shoulder area and thigh muscles, the number of micro-breaks during muscle work and the elevated position of the upper arms. It should be noted that not all muscle groups were measured with the smart clothing, e.g. the smart wear for measuring back load was not used.

Including repetitions, 111 tests were performed. In some tests the work was deliberately done incorrectly to show how poor ergonomics is reflected in the results. The tests are part of the ErgoClean project, which involves representatives from Estonia, Finland, Hungary, and the Netherlands. There are differences in cleaning methods and practices between countries. For this reason, methods that were not commonly used in all project countries were also selected for testing.

The tests were carried out in Finland during October and November 2022 in cooperation with the staff of Keuda Cleaning Services. Two cleaners were involved in the studies. Each of the employees performed two repetitions of the tested methods.

Table 1. Methods tested and compared

Damp, moist, and wet mopping
- with a mop and a squeezee mop
- S-mopping
- push-mopping
- mopping forwards
- mopping backwards
- with too long a shaft
- with too wide a movement

Damp, moist, and wet wiping
- with microfibre cloth and an interior mop
- wiping forth and back
- wiping sideways
- wiping with and without taking support
- with too wide a movement

Using cleaning machines
- scrubber driers
- vacuum cleaners

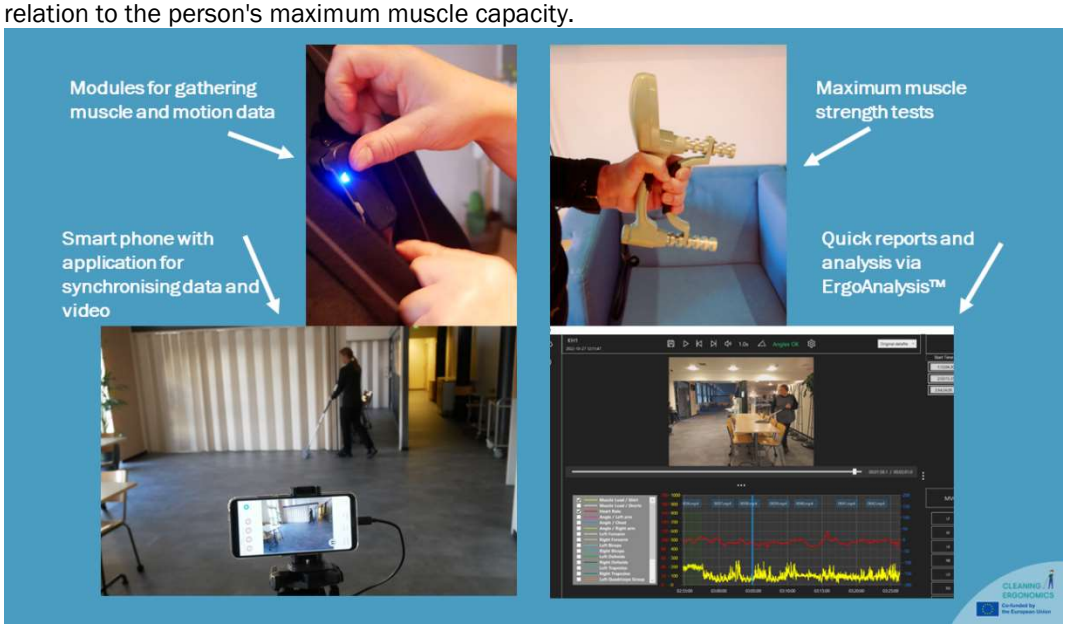
Sink cleaning with
- a brush
- a sponge
- a microfibre cloth

Cleaning a toilet seat
Wringing a cleaning cloth.

The measurements started with putting on the smart clothing and setting up the motion sensors. The maximum muscle capacities were then measured, to which the workload was related.

The measurements were videotaped on a smartphone. Measurement data and video were synchronised, allowing the video and results to be viewed using the analysis program.

Figure 1. Smart wear motion sensors measure muscle load. The measurement results are stored in the phone app along with the video. The analysis software produces a quick report of the load on different muscle groups in relation to the person's maximum muscle capacity.



What information do smart wear measurements provide?

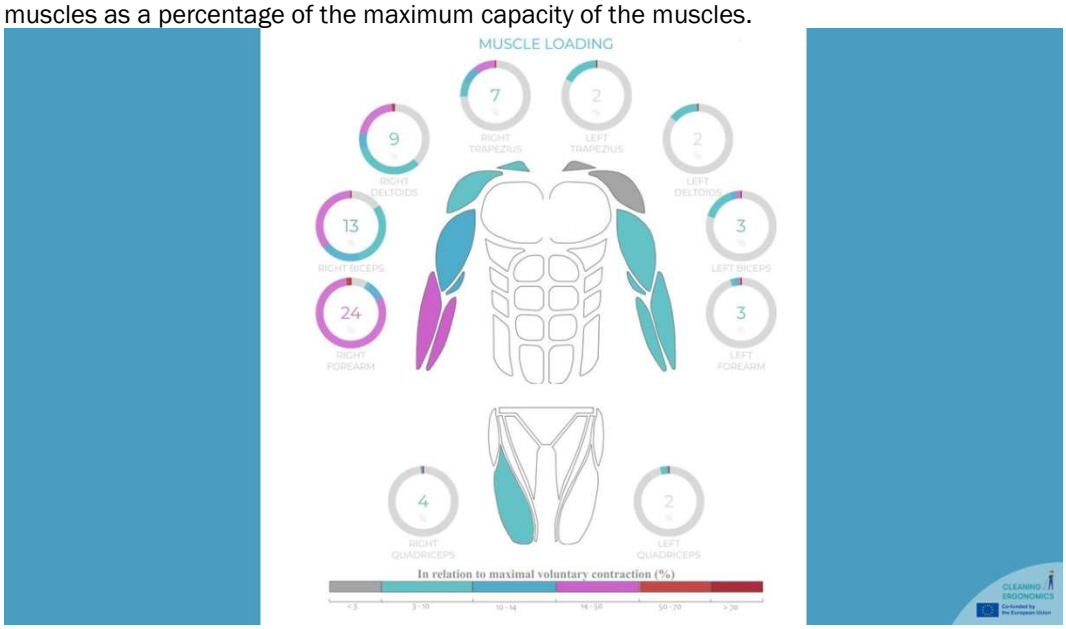
The results of the smart wear measurements are available in the form of quick reports. The reports show, by colour and percentage, the load on different muscle groups and the number of micro-breaks and shoulder elevations.

Muscle loading

The results of smart wear measurements of muscle load are expressed as a percentage of the maximum capacity of the muscle.

The results were analysed based on studies from Lund University, which found that the risk of musculoskeletal disorders increases if the percentage of muscle strain is more than 10% for more than half of the daily working time or more than 30% for more than 10% of the working time. (Anvidsson, I. & al. 2017. Åtjärdsnivåer mot belastningsskada. Arbets- och miljömedicin Syd. Rapport nr 18/2017).

Figure 2. A quick report shows the muscle load on the forearms, upper arms, deltoids, shoulders, and thigh muscles as a percentage of the maximum capacity of the muscles.



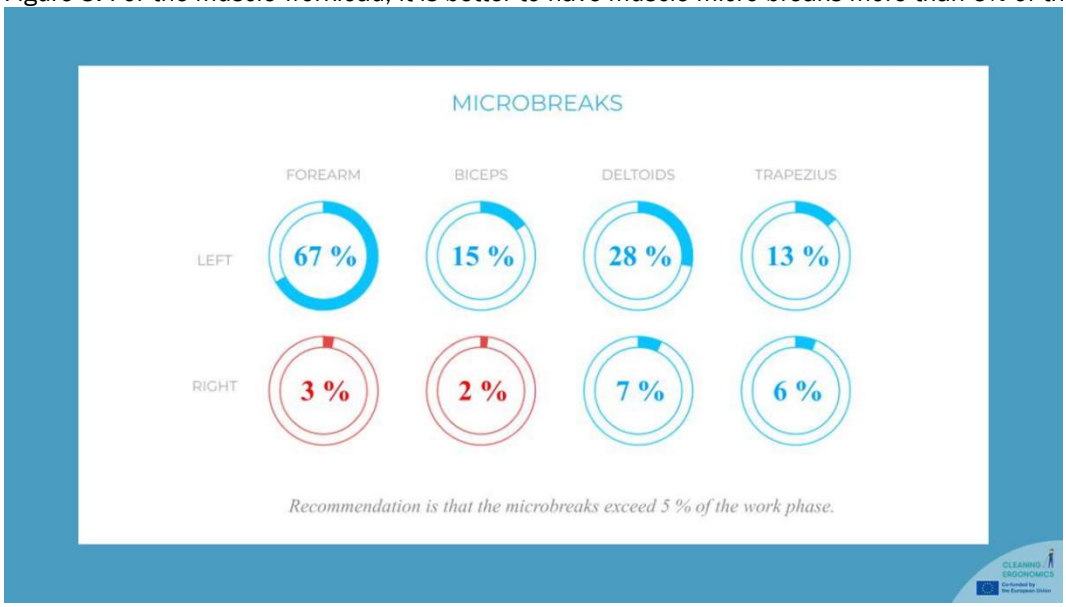
In the methods tested, the 10% threshold was almost always exceeded for at least one muscle group. For all muscles, a load of less than 10% was achieved only in damp and moist push-mopping methods and when one of the cleaners cleaned the floor with a scrubber drier.

The load on the thigh muscles was very low. No loading above 10 % occurred in any of the methods tested.

Number of micro-breaks

The number of micro-breaks gives an idea of how much work the muscle is doing statically and dynamically. To avoid unnecessary strain on the muscle, muscle micro-breaks should be more than 5% of the working time.

Figure 3. For the muscle workload, it is better to have muscle micro-breaks more than 5% of the work period.

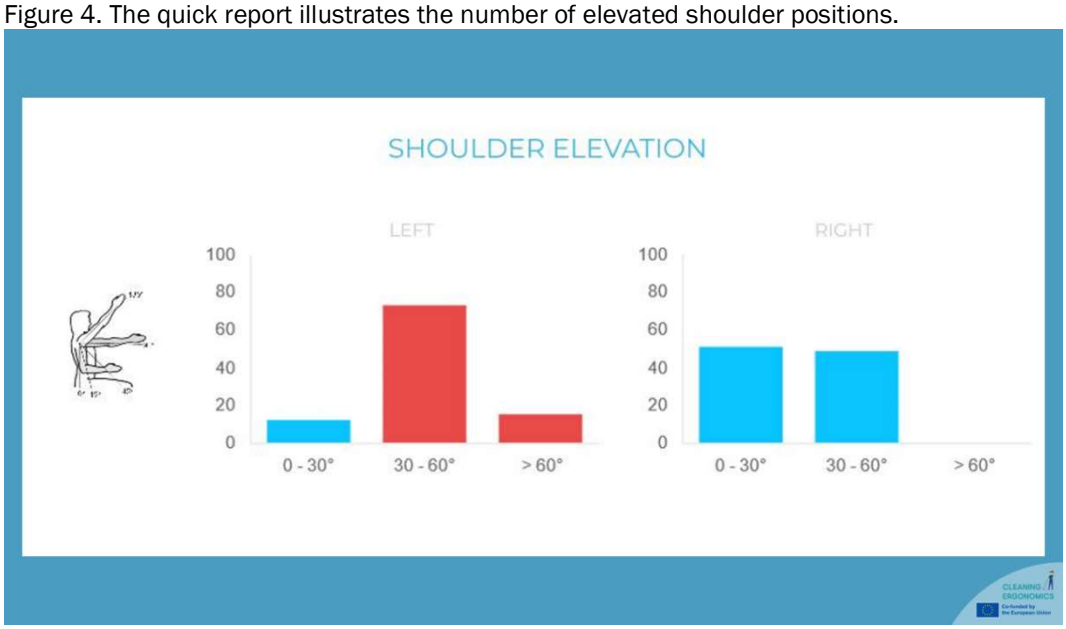


Shoulder elevation

Shoulder elevation should not be more than 30 degrees. The risk of musculoskeletal disorders increases if you work more than half of the time with your shoulders raised more than 30 degrees and your arms unsupported.

Shoulder elevation of more than 60 degrees should not occur for more than 10% of working time.

Figure 4. The quick report illustrates the number of elevated shoulder positions.



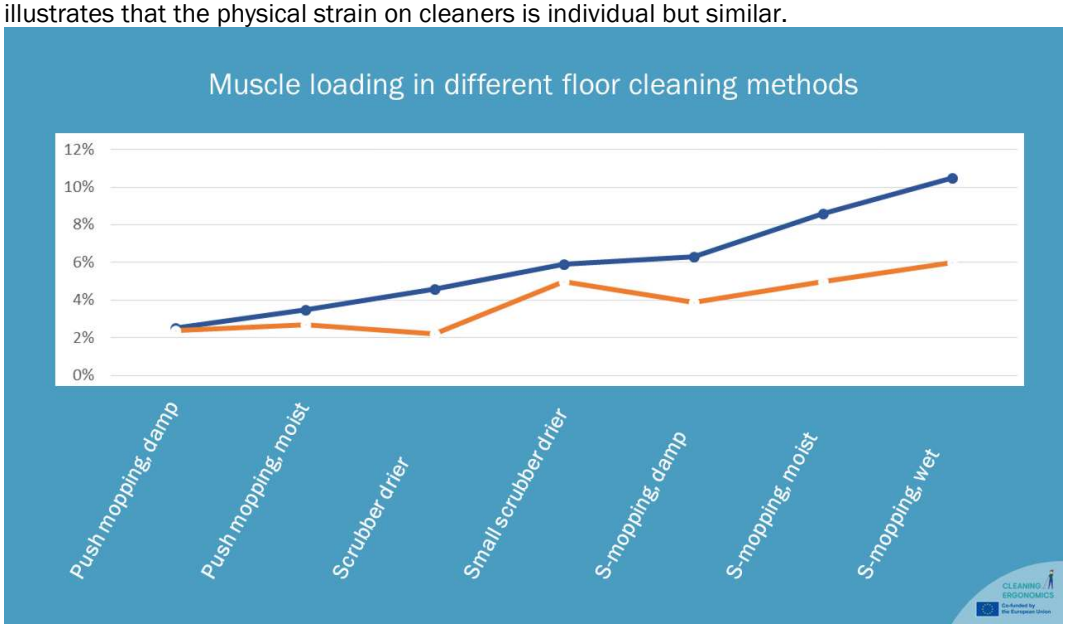
Results

Loading is individual

According to the measurements, the cleaning workload is individual. The same work method can make one person more susceptible to musculoskeletal disorders than another. Factors such as age, physical condition, weight, and state of health does matter.

Despite individual differences, the results were similar for both cleaners. This became apparent when comparing the sum variables of the load of the different methods. The sum variable takes into account the load on the different muscle groups of the arms in relation to the maximum capacities. In the method-specific results, the value of the sum variable is shown as a percentage in the muscle load graph.

Figure 5. Sum variables were calculated to compare the muscle load of different cleaning methods. The graph illustrates that the physical strain on cleaners is individual but similar.



Choose the lightest cleaning method

In Finland and Estonia, cleaning methods are divided into dry, damp, moist and wet methods. In the Netherlands and Hungary, methods are divided into dry, moist, and wet methods, with the moisture content of the moist method depending, among other things, on the surface material and dirt to be removed.

In the smart wear measurements, the workload of the damp, moist and wet methods was tested. When using a damp method, the surface dries immediately after wiping and after a moist method the surface dries in about half a minute. The wet method leaves the surface so wet that it needs to be dried.

Measurements showed that in floor mopping, the moisture content of the tool influences the load (see Figure 5). The same result was not obtained for flat furniture surfaces. We wondered whether the friction between the surface and the cleaning cloth was higher for damp wiping than for moister methods.

The working method also has an influence. Push-mopping was found to be less loading than S-mopping. A similar result was obtained when table surfaces were cleaned by push-wiping with an interior flat mop and by S-wiping.

Figure 6: Push mopping is less stressful than S-mopping.

Choose a machine over a hand tool

The use of cleaning machines makes work easier. In these studies, the use of a scrubber drier was one of the least burdensome methods. With one of the cleaners, the load on any muscle group did not exceed 10%, which is considered the threshold for exposure to musculoskeletal disorders. The other worker had a load below 10% otherwise, except for the right forearm, where the load was 11%. The diagram of the elevated shoulder positions suggests what changes could be made to the machine's push handles to make the grip less stressful.

Figure 7: Using a scrubber drier is less stressful than S-mopping.

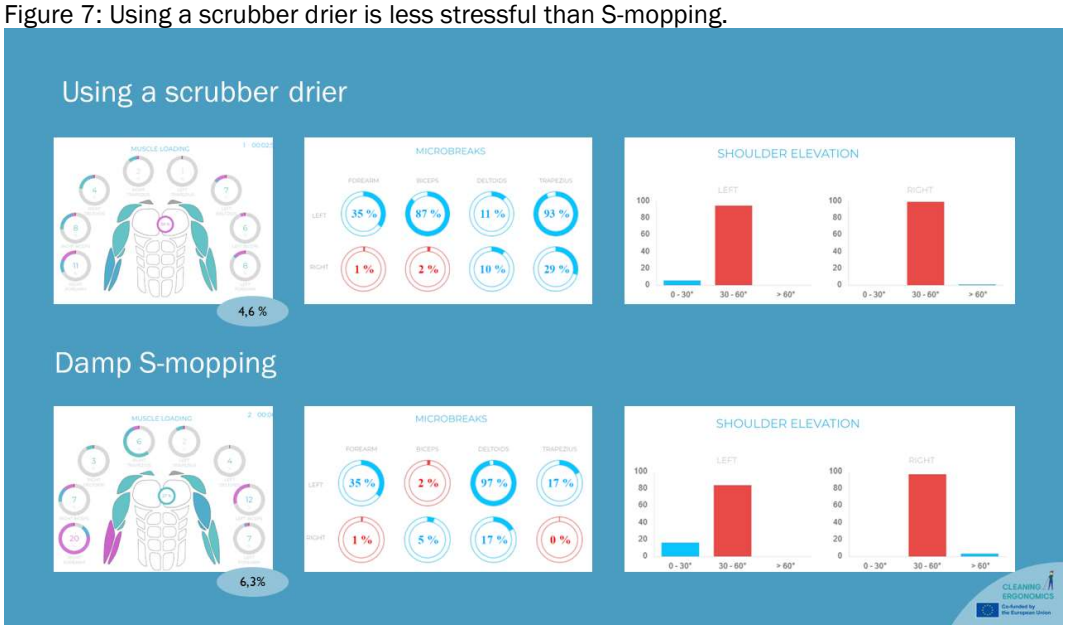
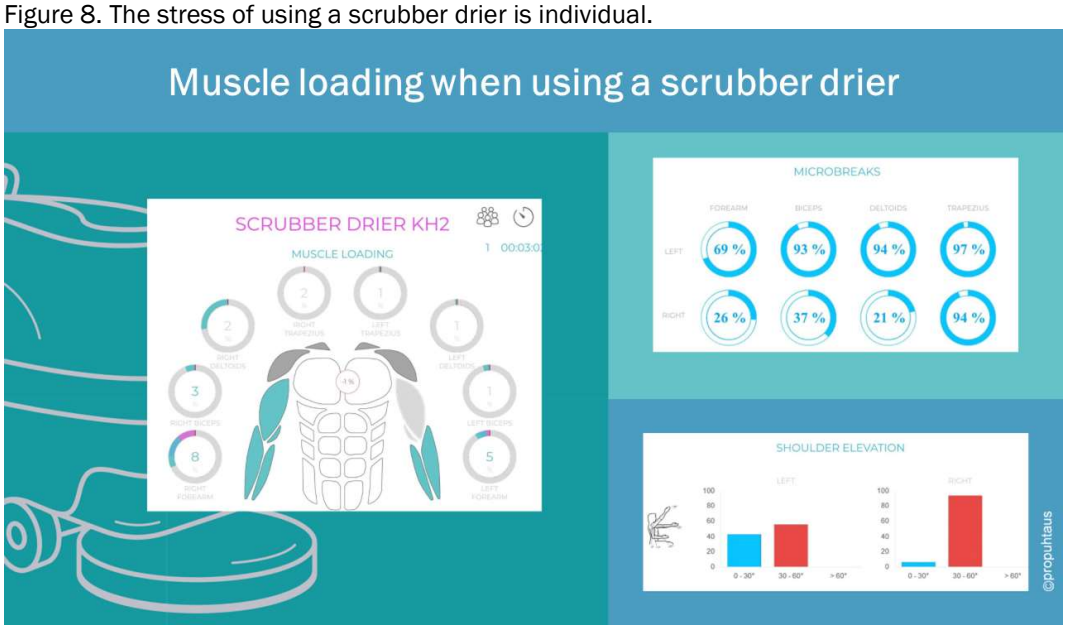


Figure 8. The stress of using a scrubber drier is individual.



When using a small scrubber drier, the load capacity was higher than the scrubber drier, but lower than the S-mopping (see Figure 5).

In the case of textile floor vacuuming, the load is significantly influenced by the working technique: whether one knows how to reduce the load by using the leg muscles to achieve the working movement or whether one uses the arm muscles.

Use the lightest tool possible

Cleaning equipment affects the workload. We compared a microfibre cloth and a flat interior mop for cleaning flat surfaces, a mop and a squeezee mop for mopping floors, and a dish brush, sponge and microfibre cloth for cleaning sinks.

We noticed that it is important to master the correct use of the tool. If the tool is not used correctly, the load may be at the beginning greater than with a familiar tool.

According to our measurements, from the point of view of workload, it is better to choose a flat interior mop for cleaning flat surfaces and a squeezee mop for mopping floors.

Figure 9. Using a squeezee mop is less stressful than using a mop if the tool is known.

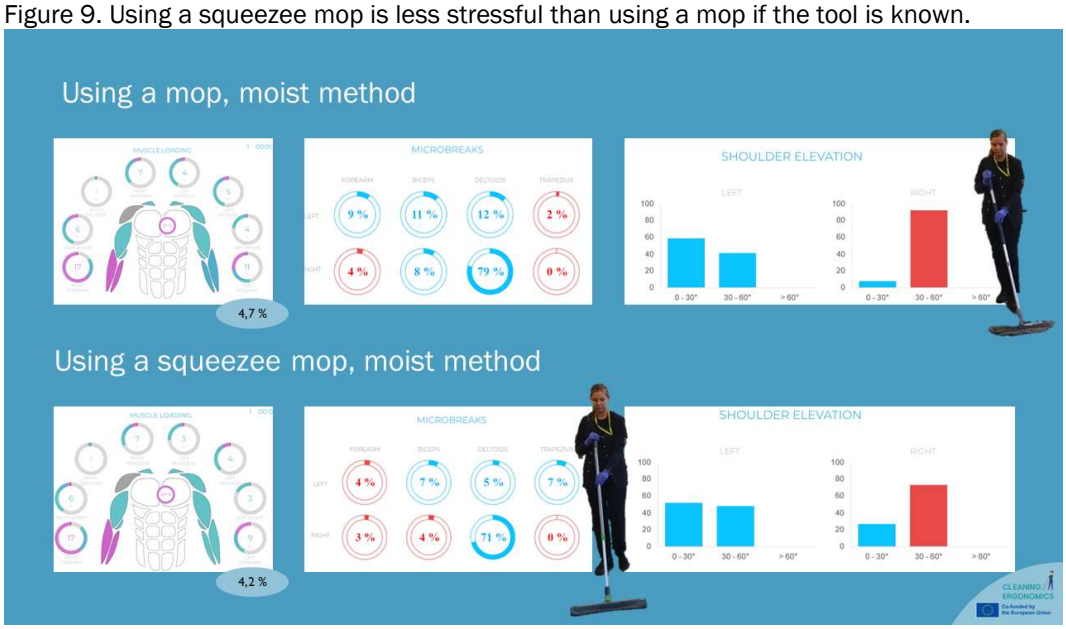
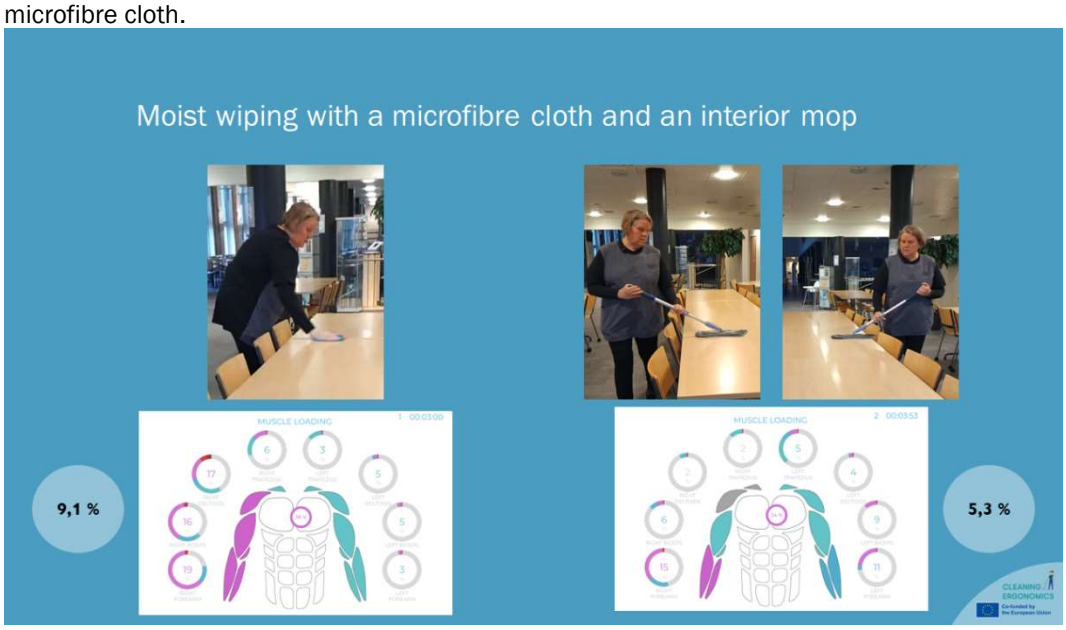
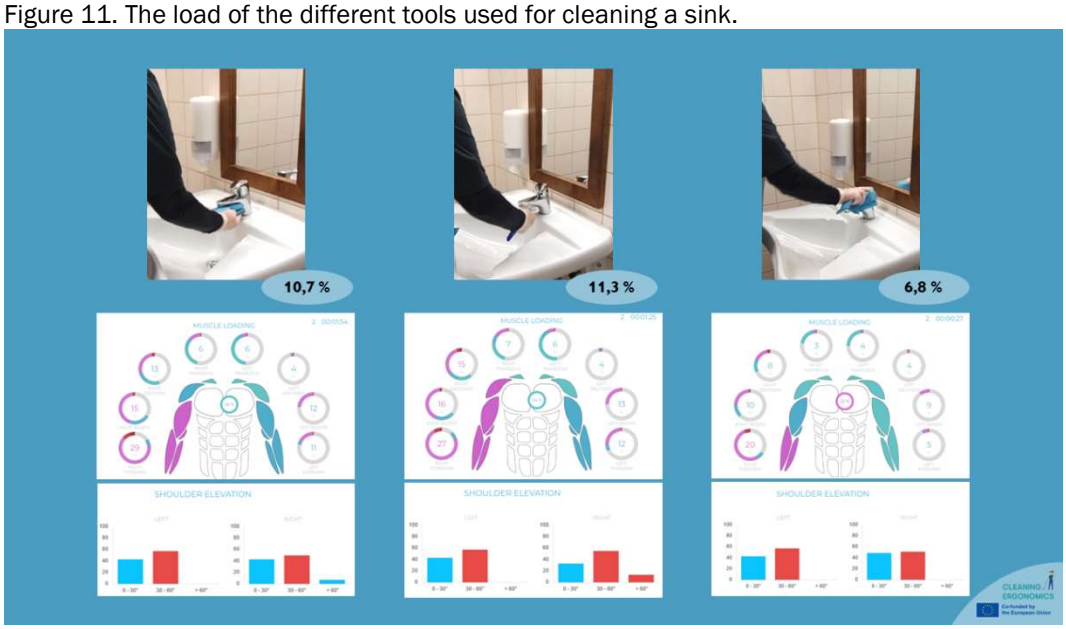


Figure 10. In all wiping methods, the use of a flat interior mop was less stressful than cleaning the surface with a microfibre cloth.



When cleaning a sink, the use of a microfibre cloth or a sponge was less burdensome than using a dishwashing brush.

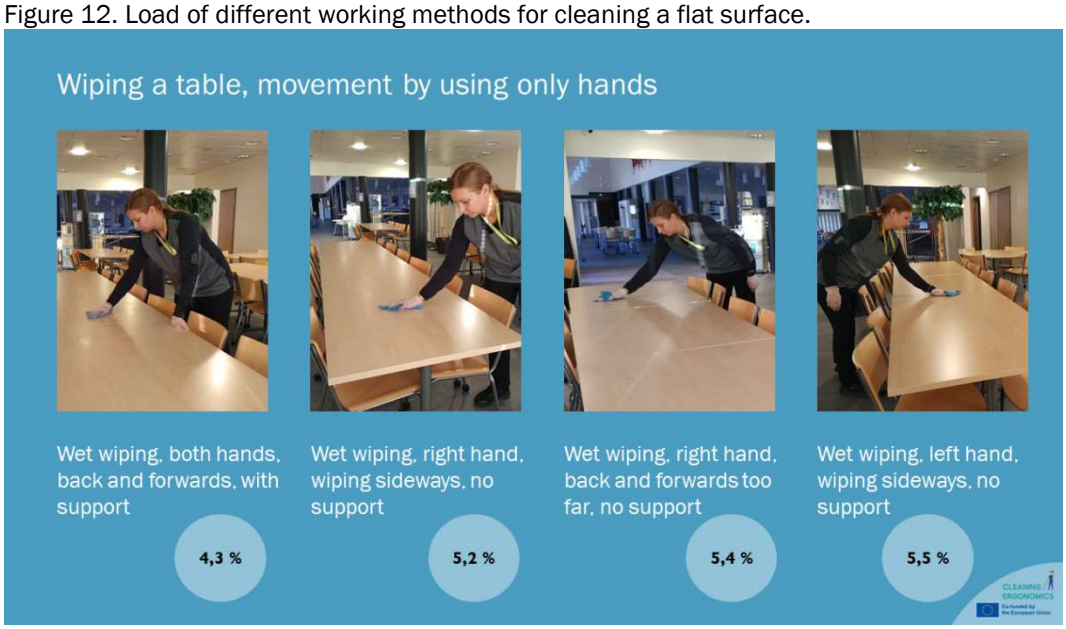
Figure 11. The load of the different tools used for cleaning a sink.



Practice the most ergonomic way of working

There are several ways to reduce hand strain. Traditionally, ambidexterity is recommended, but this requires good control of the work to reduce the load. Our tests showed that ambidexterity is not useful unless you can do the work smoothly with both hands. Training is therefore needed to be able to wipe a flat surface, for example, correctly and fluently with both right and left hands.

Figure 12. Load of different working methods for cleaning a flat surface.

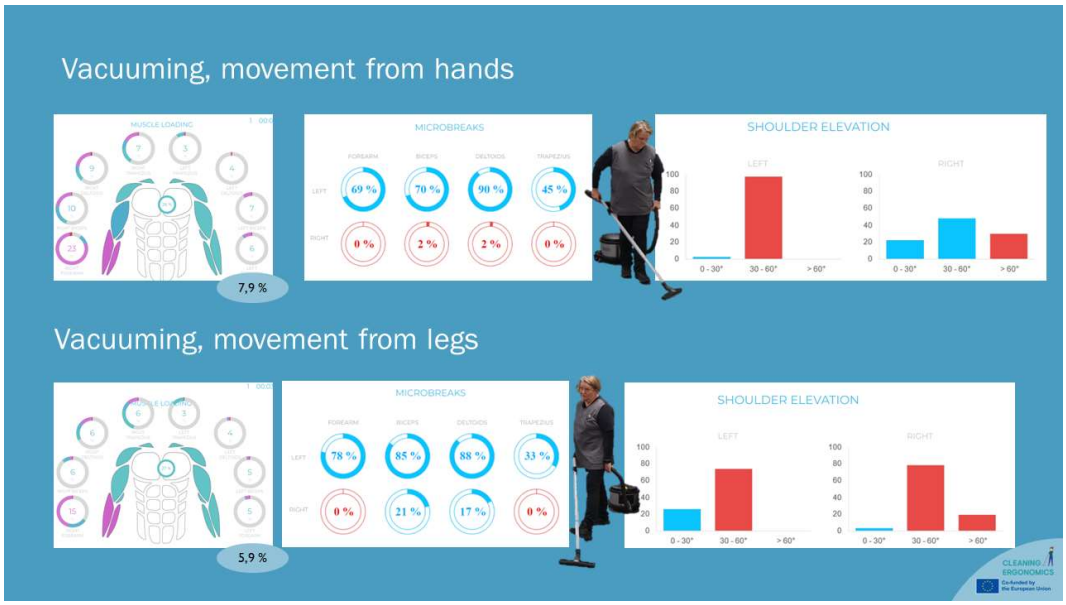


Use the leg muscles

Both cleaners were right-handed. The quick reports show that the right forearm was the most loaded arm in most of the methods.

The load on the arms can be reduced if you can make use of the movement of the legs during the work. In our tests, the muscle loading was lower when wiping and vacuuming if legs were used to produce movement. Work with the hands is lightened when the centre of gravity of the body is brought closer to the area to be cleaned by the movement of the feet. A recommended working method that is worth learning

Figure 13. The load is reduced if the working movement during vacuuming is produced by the movement of the feet.



Mopping backwards or forwards?

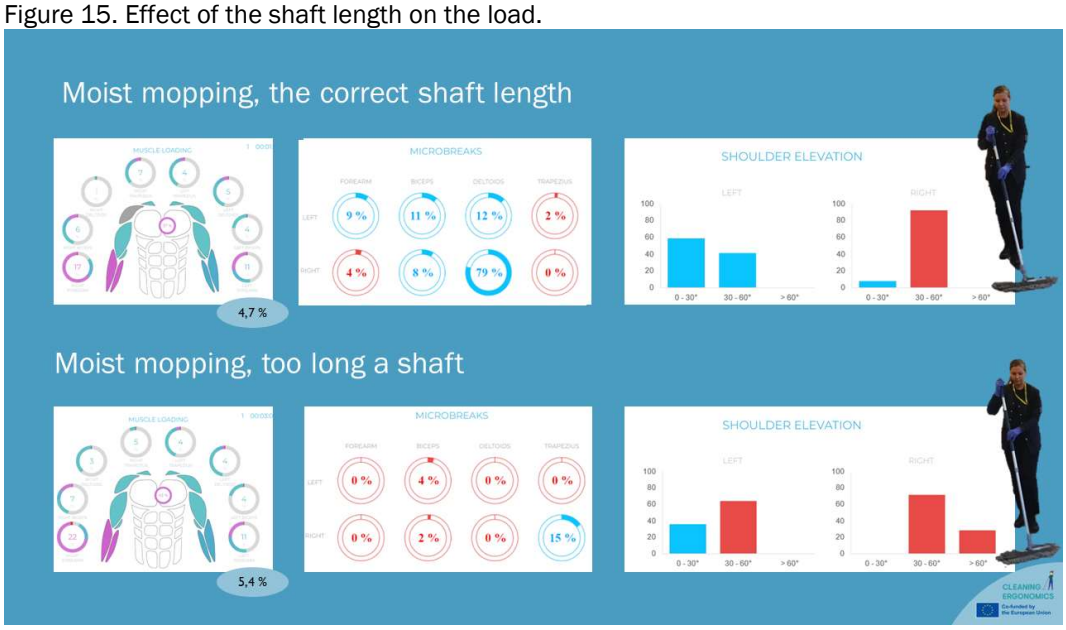
The way of mopping varies from country to country. In Estonia and Finland, it is recommended to mop the floor moving forward. The reasoning is to see the dirt and for safety reasons - you can see where you are going and you don't have to twist your torso and neck when looking backwards. In the Netherlands and Hungary, mopping is often done by moving backwards to avoid walking on the cleaned surface.

Figure 14. Load of mopping methods

Avoid: Too long a shaft

We also deliberately tested ways of working that we thought were wrong or bad. The measurements clearly showed the importance of the correct length of the tool shaft. If the upper palm repeatedly rises above the shoulder level when mopping, the load is reflected in the forearm and possibly also in the upper arm.

Figure 15. Effect of the shaft length on the load.



Adjusting the shaft to the right length is all the more important when using heavy cleaning methods.

Below are the results of wet mopping forwards and backwards for both workers when the shaft was set too long. The figure shows that there are also shoulder elevations over 60 degrees. Positions above 60 degrees should not occur for more than 10% of the working time.

Figure 16: Wet mopping load for person A.

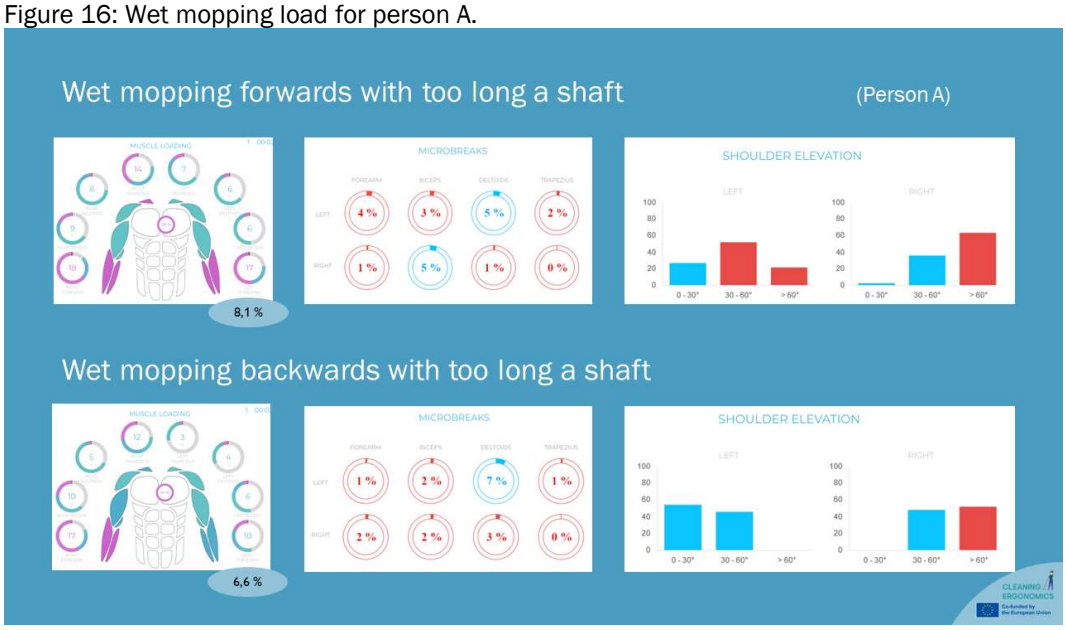
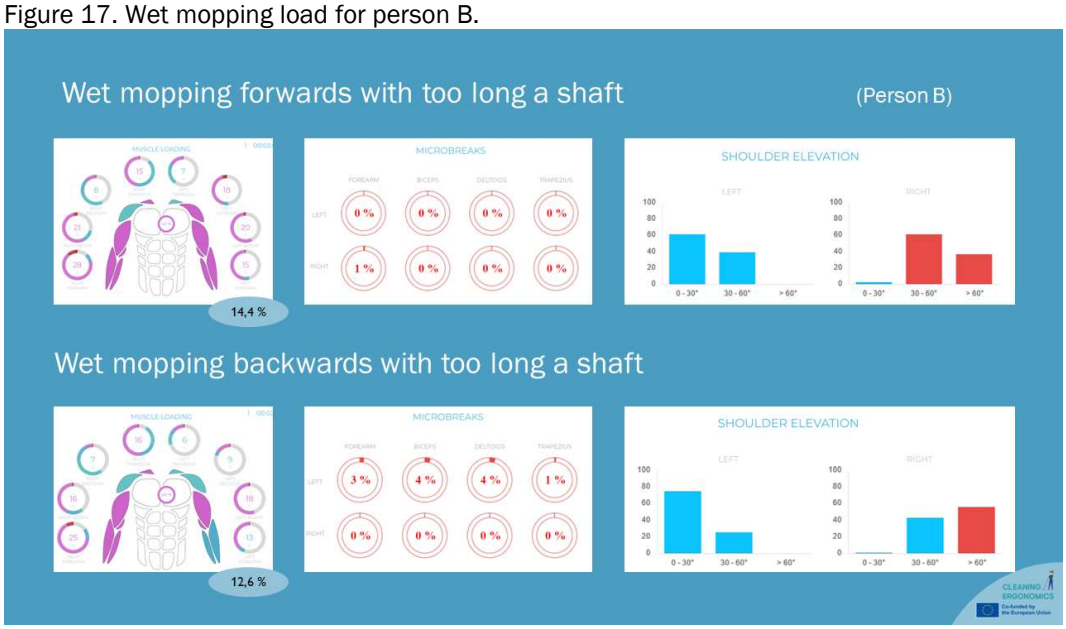


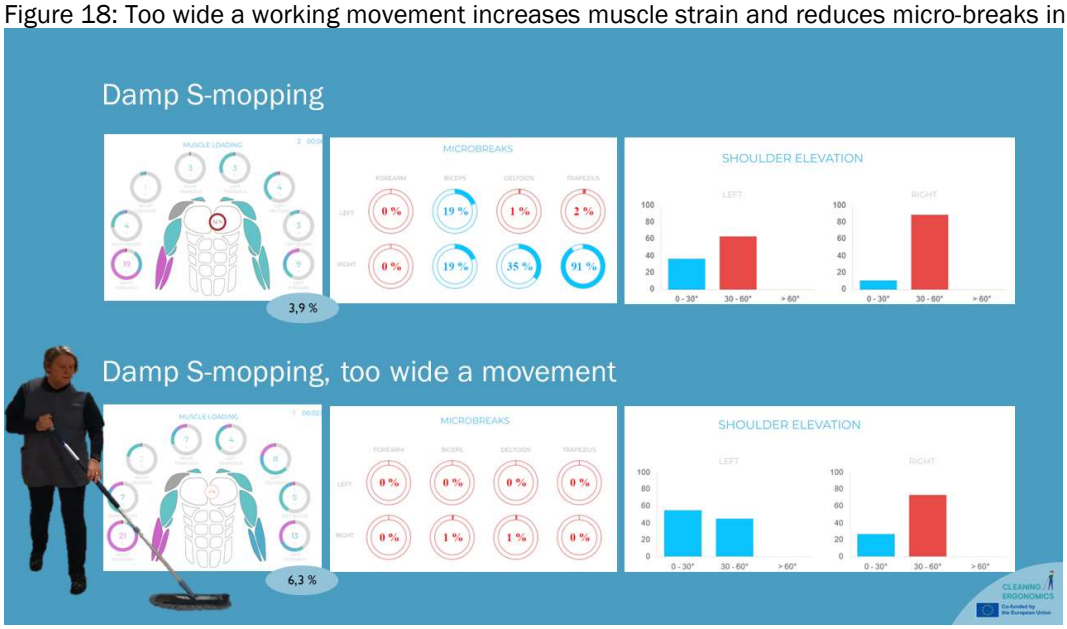
Figure 17. Wet mopping load for person B.



Avoid: Too wide a movement

The right forearm is stressed by too wide a mopping movement.

Figure 18: Too wide a working movement increases muscle strain and reduces micro-breaks in muscle work.



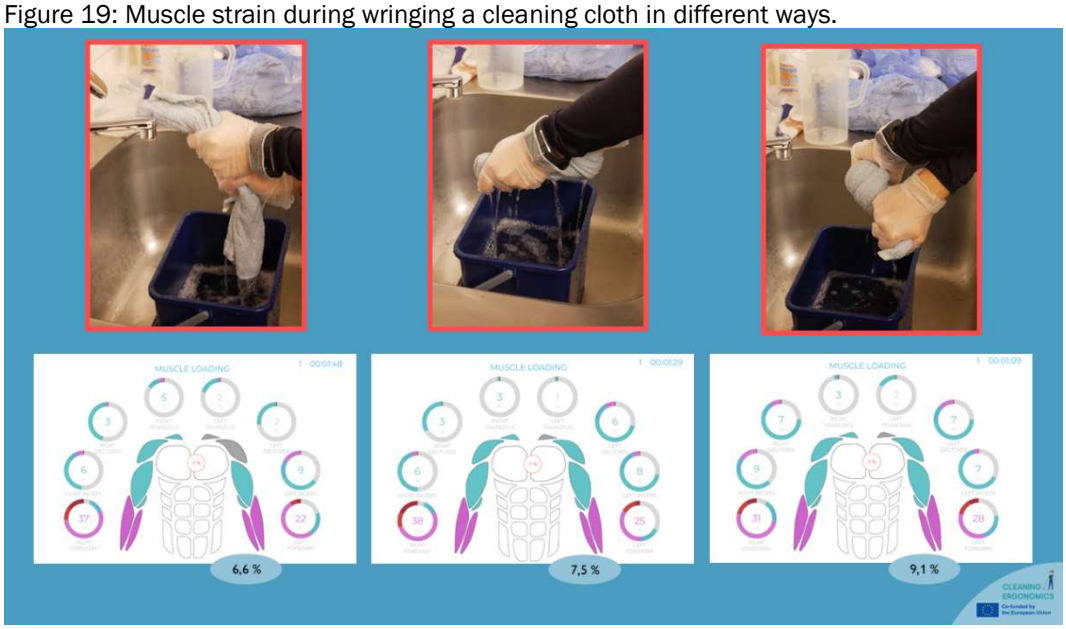
The lateral working movement is also a strain when wiping flat surfaces, where a back and forth working movement in the mid-torso area is recommended.

Avoid: Wringing, pre-moisten

Pre-preparation of cleaning textiles is recommended. By pre-moistening cleaning cloths and mops at the beginning of the working day and not having cleaning solutions in buckets in a cleaning trolley, manual wringing of the cloths is avoided.

However, we tested different ways of wringing a cleaning cloth. The load on the forearms of the right hand exceeded 30%. The risk of musculoskeletal disorders increases if the 30% load lasts for more than 10% of the daily working time.

Figure 19: Muscle strain during wringing a cleaning cloth in different ways.



Conclusions

The quick report images produced by the smart wear measurements help to visualise the muscle load. The red colour in the images draws attention to and highlights the muscle groups under load, the static nature of the muscle work in terms of the low number of micro-breaks and the number of elevated positions of the upper arms during the work.

The images can be used to justify the need for careful selection of the working method, tool and working style in situations where different alternative cleaning methods are available for removing dirt.

The measurements also highlighted the importance of correct tool use. Using a new tool can be initially more stressful than using a familiar tool. Therefore, when a new tool is introduced, its use should be practised so that the correct working method is adopted from the start.

Cleaning workloads are individual, but our measurements show that they are consistent and similar. The load is influenced, among other things, by the age of the person. Ergonomic working methods should be learned from the beginning of a career in order to avoid unnecessary strain on the body.

According to the measurements, the load on the thigh muscles was very low. In cleaning work, it would be useful to learn to use the strength of the leg muscles in the working movements and thus reduce the strain on the arms.

Attention should therefore be paid to working postures and to how to work. In cleaning, repetitive work over a long period of time increases the risk.

Once you have familiarised yourself with the pictures, it will be clear how you should at least not do cleaning work. For example, you should not mop with the tool handle too long, mop with too wide a mopping movement even when you are in a hurry, or mop if you can use a scrubber drier.

However, when looking at the results, it is important to bear in mind that there are many factors that influence the choice of cleaning method. For example, this study did not investigate the cleaning performance of different methods or tools. In addition, not all muscle groups were included in the measurements, for example, the load on the back muscles was not measured.

These measurements were used to investigate the stress caused by individual working methods. In the future, it would be useful to investigate the load on the back as well as the load over the whole working day.

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