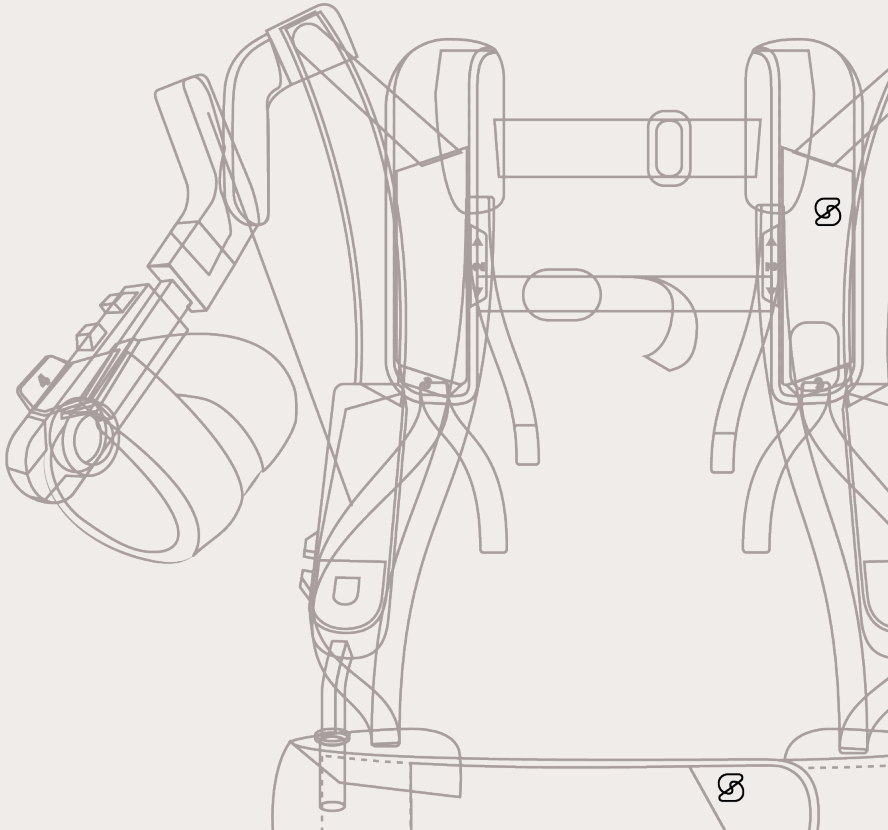
skelex

Research Evidence Sheet

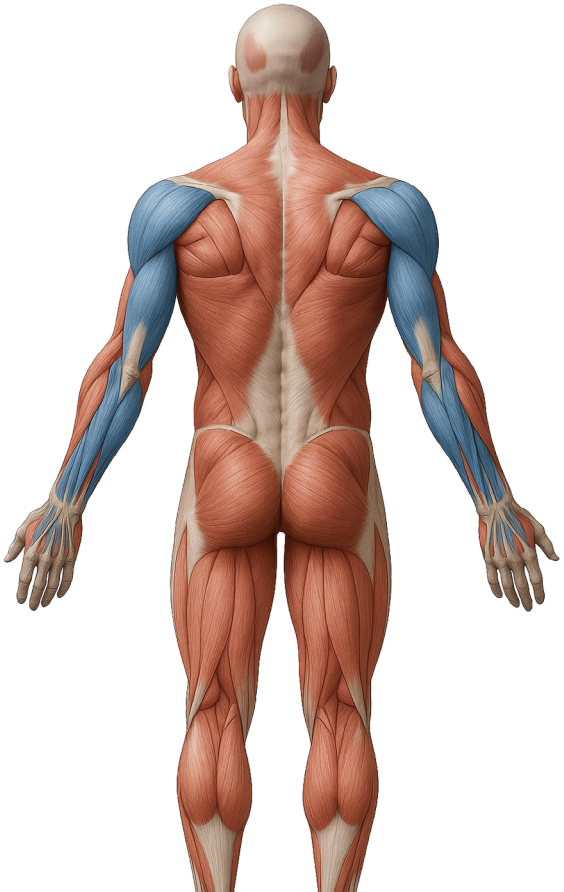
Skelex **360**

Science on your **shoulders**



Proven reductions in strain and fatigue across multiple tasks

Hundreds of studies have shown how exoskeletons reduce strain and fatigue, but the volume of research makes it difficult for non experts to see what really matters. This document brings the evidence together in a clear and practical way, focusing on key tasks such as **welding, sealing, overhead assembly, lifting, plastering, and ceiling construction.** It also highlights critical indicators like fatigue and precision. Across all use cases, the findings point to Skelex 360 as a trusted solution, validated in both laboratory studies and real working environments.



Benefits

By supporting the shoulders and arms, Skelex 360 makes overhead work more sustainable. Research has shown that it:

Reduces muscle activity in the shoulders by 30% to 50%

Lowers the feeling of heaviness and fatigue

Does not interfere with accuracy or fine motor skills

Keeps heart strain lower during repetitive tasks

Cardiac costs

A study of the Ecole Centrale de Nantes (FR), proves that Skelex 360 reduces fatigue based on measurement of cardiac cost [1]

In this study, influence of Skelex 360 on cardiac cost was studied for repetitive (R) and precise (P) tasks. A total of 36 healthy participants, 18 males and 18 females, participated in the study. Task R involved using a 6 kg power tool for fastening nuts with arms elevated near eye height. Task P involved drawing lines that were projected on a wall with an interactive pen, shown in Fig 1a.

For both tasks, significant reduction in cardiac costs was observed while wearing an exoskeleton, despite the added weight and physical constraints. This was validated by subjective questionnaires evaluating global and local perceived effort which showed statistical significant reduction both globally and locally, especially for shoulder, arms and neck, as shown in Fig 1b. Reduction in cardiac cost while wearing Skelex 360 indicates lower fatigue experienced while performing a task – combined with earlier EMG studies conclusively establishes that using Skelex 360 for certain tasks will make users feel less tired.

Fig 1a. A participant performing the precision task P without exoskeleton (a) and with the exoskeleton (b).

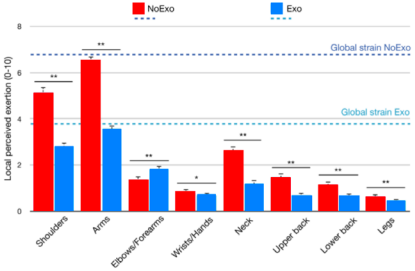


Fig 1b . Global and local perceived effort for specific parts of the body without (NoExo) and with Exoskeleton (Exo) for all tasks; dotted lines indicate global strain means.

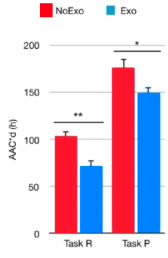


Fig 1c . Evaluation of ACC*d (h) for Task R and task P with (Exo) and without (NoExo) exoskeleton.

Precision

Influence of Skelex 360 on fine motor control while performing precision tasks was studied in this research [2] which concludes that using the Skelex 360 allows workers to maintain precision while reducing muscle activity, even under fatigue.

The study of a.o. the University of Hamburg and Institut Universitaire de France [2], investigated the impact of Skelex 360 in the presence of muscular fatigue or not, while performing single (ST) and dual (DT) industrial tasks consisting of speed and accuracy exercises. In both scenarios, N = 10 participants (5 male/5 female) engaged in an overhead precision task using a nail gun to precisely target specific areas on three differently sized regions, based on Fitts' law paradigm (speed-accuracy trade-off task), with and without Skelex 360 (Fig 2a).

Substantial muscle activity reduction was observed in M. deltoideus muscle for ST-26% before fatigue, 32% after fatigue; DT -53% before fatigue, 40% after fatigue; this is consistent with EMG results from other research while wearing Skelex 360, as shown in Fig 2b.

Most importantly, it was concluded that i) healthy young participants can easily adapt to the use of Skelex 360 to perform a fast and accurate task, and ii) wearing Skelex 360 does not alter the ability to manage the speed-accuracy trade-off.

Fig 2a. (from left to right) Utilization of the nail gun without the exoskeleton. Utilization of the nail gun with the exoskeleton, Fatigue protocol

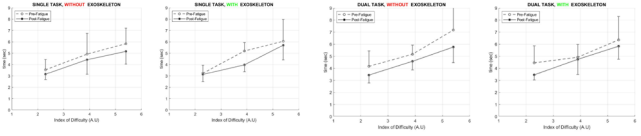


Figure 2b. Fitts' Law was preserved across all conditions (exo/no exo, fatigue/no fatigue, ST/DT). The slope remained unchanged, suggesting that participants adapted motor strategies to maintain control. While wearing an exoskeleton, users could still perform accurate, timed movements reliably

Sealing

Aerospace manufacturing involves several tasks involving arm elevation; research of Wichita State University (USA) [3] shows that Skelex 360 is one of the best solutions for supporting craftsmen executing these types of tasks

Aircraft manufacturing involves an operation called sealing during which fuselage joints are sealed utilizing a sealant and smoothing tool, requiring motion of a worker's arms at heights below the elbow to overhead (Fig 3a). The participants for this study consisted of 16 experienced aircraft manufacturing employees (8 males, 8 females).

Research evaluating passive upper-arm exoskeletons during aerospace sealing tasks demonstrated a substantial reduction (30–40%) in trapezius muscle activation (Fig 3b).

The study highlighted Skelex 360 as the most comfortable device among those tested, significantly improving both worker comfort and precision in overhead sealing operations (Fig 3c).

Fig 3a. Horizontal sealing tasks and starting postures (from left to right) a) standing sealing along upper stringer b) standing sealing along lower stringer c) seated sealing along upper stringer d) seating sealing along lower stringer

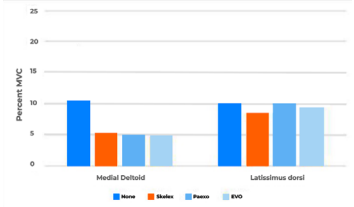


Fig 3b. Mean percent MVC for preferred side muscles significantly affected by exoskeletons during standing horizontal sealing

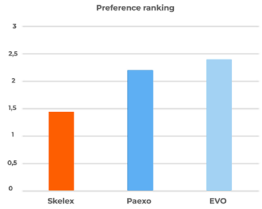


Fig 3c. Mean exoskeleton preference ranking for use during sealing tasks (1=most preferred to 3=least preferred)

Welding

Research carried out by Fraunhofer IPA (DE) [4] research showed improvements in welding performance with Skelex 360

Welding is a common manufacturing process with more than 1 million welders working globally in shipbuilding, infrastructure and other industries.

A study designed by Fraunhofer IPA with 15 subjects having welding experience involved 1-hr workflow that abstracts welding and grinding tasks with a welding simulator, focusing on PF Position (vertical welding in front of body), and PE Position (overhead welding (Fig 4a). The welding simulator rated "travel speed" — a key factor in weld quality — on a scale from 0 to 100.

Position PF (vertical welding in front of body) showed an improvement of +5.8% when using Skelex 360. For Position PE (overhead welding), the improvement was + 28.8% (Fig 4b). The score of the welding parameter travel speed, which is essential for the permissibility of the seam, shows a statistically significant increase when Skelex 360 is used.

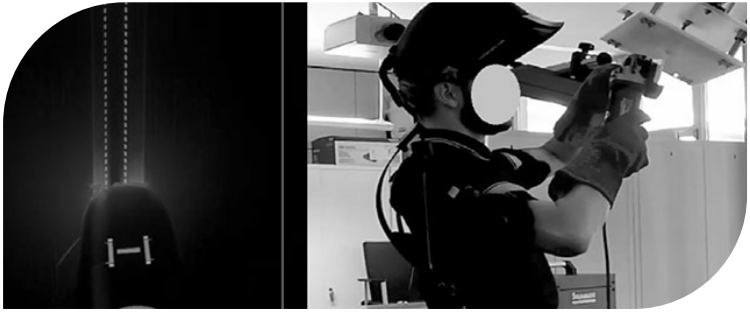


Fig 4a (left) First-person view of the subject for position PF during welding sequence; (right) Exemplary illustration of the Position PE during grinding sequence

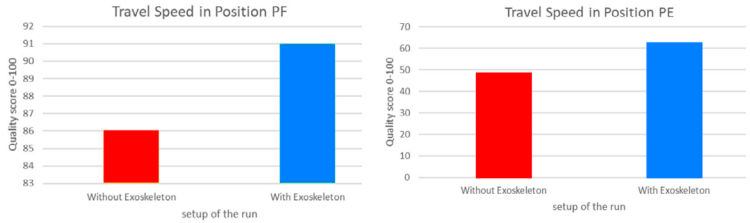


Fig 4b. Results of the statistical analysis of the parameter travel speed for the entire population

Plastering

A reduction in shoulder muscle activity was observed in an application study of TNO (NL) [5] during plastering tasks, using Skelex 360

Plastering ceilings involves long sequences of complex overhead movements with heavy plastering tools, which rapidly leads to fatigue in shoulders, arms, and upper back.

In this study, 11 experienced plasterers performed typical plastering tasks, such as applying plaster on the wall, the ceiling and finishing the wall or ceiling in a special setup (Fig 5a). The muscle activity with and without Skelex 360 was measured with EMG sensors. Significant reductions in muscle activity were found for some shoulder muscles when using the exoskeleton, while none of the muscles studied showed a significant increase in activity in any of the tasks (Fig 5b).

This unique study further validates the efficacy of Skelex 360 for difficult overhead tasks by objective measurements in a real-life scenario.

Fig 5a. Overview of the set-up and activities on the ceiling. screeding (left) and finishing with a plastering spatula (right).

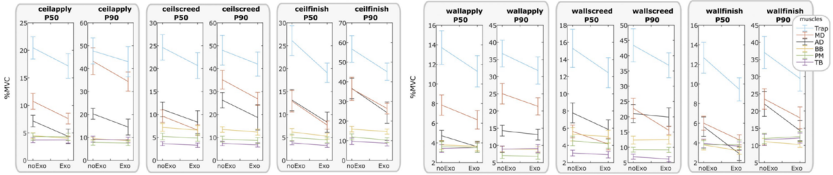


Fig 5b. Muscle activation in Exo and NoExo conditions for different plastering tasks. Each panel represents one plastering task, upper row shows working on the wall, lower row shows working on the ceiling.

Overhead assembly

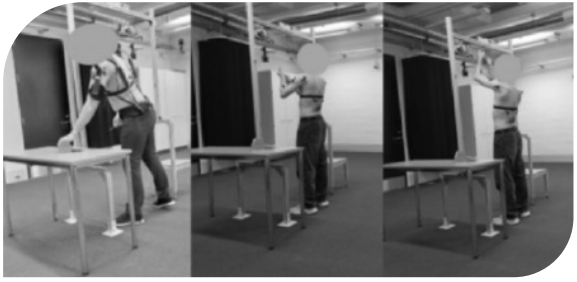
A study from the Aalborg University (DK) [6] found that Skelex 360 reduces muscle activity in both dominant and non-dominant arms during overhead assembly tasks

Overhead assembly requires one arm to hold or stabilize while the other performs the main action, leading to rapid fatigue in both arms. The supporting, non-dominant arm often experiences the highest strain.

In this study the impact of Skelex 360 on muscle activity was investigated experimentally for an overhead assembly task. Eighteen healthy males participated in the study. The task involved picking up a screw with non-dominant hand and screwing it with dominant hand, for a total of 10 screws per subject, as shown in Fig 6a.

The results showed a reduction in muscle activation across all muscles, shown in Fig 6b. An interesting observation is that the reduction in muscle activity was substantially higher for the non-dominant hand,

This contributes to the overall subjective feeling of fatigue even for simple tasks that require both hands – these are extremely common across many industries.



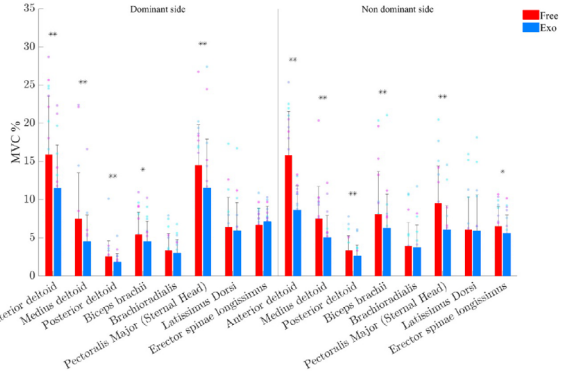


Fig 6a (above). Overhead Assembly Task setup
Fig 6b (below). Comparison of the mean muscle activation between participants in the two conditions, Free (gray) and Exo (orange), during the overhead assembly task.

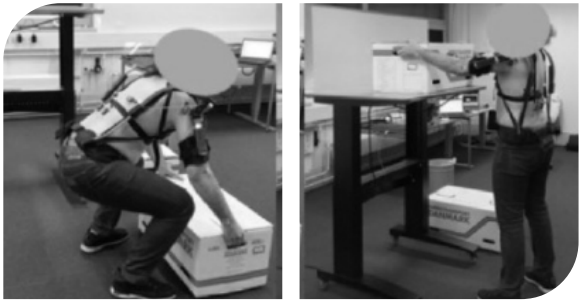
Lifting

A study of Aalborg University (DK) [6] observed a reduction in shoulder muscle activity during repeated lifting tasks when using Skelex 360

Moving or lifting objects is a common task but known to cause MSDs, in this study, the influence of an exoskeleton on muscle activity was investigated experimentally for a lifting task.

Eighteen healthy males participated in the study. The task involved lifting a box (W=10 kg) from the floor to the top of a table, while rotating the body 90 degrees, as shown in Fig. 7a. A pace of 15 repetitions per minute was imposed using a metronome. Participants performed six consecutive lifts and repeated the entire task three times for each condition, both with and without Skelex 360.

The results show that AD (Anterior Deltoid) and MD (Medial Deltoid) activation was significantly reduced on both sides using the Skelex 360 (Fig 7b). Interestingly, certain muscle groups showed an increase in muscle activation; this could be due to the back being constrained by the structure. Hence, for highly dynamic tasks such as lifting, even with a device as flexible and comfortable as Skelex 360, some users may experience a feeling of being constrained by the device.



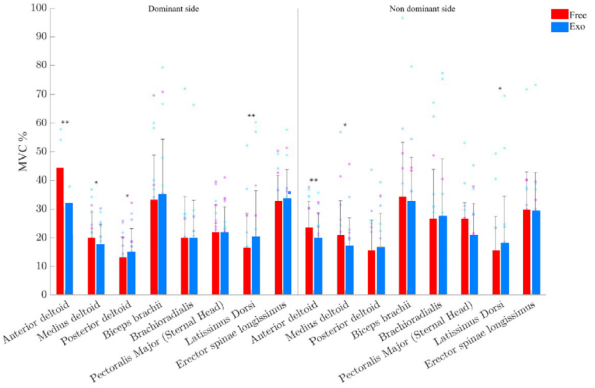


Fig 7a (above). Overhead Assembly Task setup

Fig 7b (below). Comparison of the mean muscle activation between participants in the two conditions, Free (gray) and Exo (orange), during the lifting task.

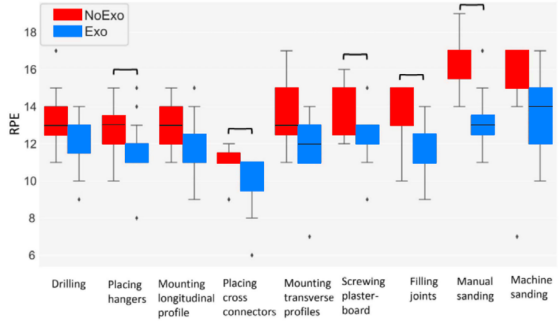
Ceiling Construction

TNO (NL) [7] observed significant reductions in shoulder muscle activity and perceived exertion during ceiling construction tasks when using Skelex 360

Constructing a ceiling involves continuous arm elevation which is a risk factor for MSDs. This study of TNO further expands on usage of Skelex 360 in the construction environment.

11 experienced ceiling constructors performed 9 different tasks involved in constructing a ceiling, with and without Skelex 360, as shown in Fig 6a. Each participant had the choice to perform the tasks as per their preference, with each task lasting between 3 – 4 minutes. Both objective (EMG) and subjective Rate of Perceived Exertion (RPE) evaluation was carried out in a simulated, but realistic environment.

EMG results show substantial reduction in muscle activity, in line with earlier research. RPE was lower across all tasks as shown in Fig 8a, but clear preference was to use Skelex 360 for machine sanding, manual sanding and filling joints, which are the heaviest jobs. 10 out of 11 subjects preferred the use of the exoskeleton for the tasks as shown in Fig 8b. These results further validate that for the right tasks, even if they are complex, Skelex 360 provides flexibility and support.



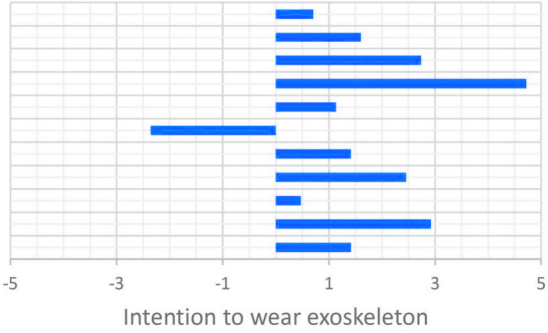


Fig 8a (above). Boxplots of Rate of Perceived Exertion (RPE) in the dominant arm
Fig 8b (below). Participant's intention to wear the Skelex 360 when weighing benefits and drawbacks. The higher the values, the higher the intention; the lower the values, the lower the intention. Each horizontal line represents the answer of a single participant.

References

This document presents results from independent research carried out in collaboration with universities and institutes. All findings are based on EMG measurements, RPE data, and performance tests in real industrial tasks

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