# The Effect of a Tilt Cabin Reach Truck on Muscle Activation and Perceived Driver Experience

by

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## Introduction

Forklift trucks are essential in industrial and logistics operations but often involve physically demanding tasks that contribute to musculoskeletal strain, particularly in the neck, shoulders, and back. In Sweden, forklift operators report high rates of work-related musculoskeletal disorders (Flodin et al., 2018). One key ergonomic challenge is repeated upward head tilting during high-lift work. To address this, Toyota Material Handling Europe introduced tilting cabin designs to promote a more neutral working posture. A recent Swedish study found that operators perceived tilting cabins as reducing neck and shoulder strain and improving visibility during high-lift tasks (Turén & Thorslund, 2026). While cabin tilt is primarily intended to reduce physical strain, it may also influence cognitive aspects of task performance. Improved visibility can support visual information gathering, reduce the effort required to monitor loads at height, and alter how operators engage with the task environment. Understanding the relationship between objective physiological measures and operators' subjective experiences is therefore relevant not only from an ergonomic perspective but also for understanding perception and task engagement in applied work settings. Building on this, the present study combines subjective evaluations with objective measures of muscle activation in a controlled setting, where participants performed identical tasks with and without cabin tilt. The objective methodology follows Ahlström et al. (2019), using surface electromyography (sEMG) to assess muscle activation. Earlier work on reach trucks showed that tilt reduced head extension by approximately 20% (Cederqvist, 2000). In contrast, sEMG provides a more direct assessment of muscular load rather than observable movement alone.

## Aim and research questions

The aim of this study was to evaluate how a tilting cabin in reach trucks affects operators' physiological workload and subjective experience during high-lift tasks compared to a conventional fixed cabin. Particular attention was given to the relationship between measured

muscle activation and operators' perceptions of visibility, comfort, and work performance. The following research questions were addressed: *(RQ1) How does cabin tilt influence activation of the sternocleidomastoid, neck extensor, and upper trapezius muscles? (RQ2) How do working height and cabin tilt interact to affect muscle activation? (RQ3) How do operators describe visibility, comfort, and strain when using cabin tilt?*

## Method

This within-group study was conducted at Toyota Material Handling Europe's facilities using one of their trucks, with and without the tilt-function active. Neck muscle activation and operators' experiences was measured through sEMG and semi-structured interviews.

### Participants

Twenty-two experienced reach-truck operators were recruited from Toyota Material Handling Europe and its customers. Participants were aged 21–56 years; 13.6% identified as female, 81.8% as male, and 4.5% did not report gender. On average, they reported 31.8 hours of weekly operation and 13.3 years of certification experience. All participants had prior experience with tilting cabins and reported using this function in their current work.

### Equipment

The study used a Toyota BT Reflex reach truck equipped with a tilting cabin, with a maximum reach height of 11 m (Figure 1a). sEMG was recorded using self-adhesive Ag/AgCl Neuroline electrodes. A total of 13 electrodes were connected to a Vitaport 3 amplifier. Two electrodes were placed on six individual muscles across three muscle groups, with an inter-electrode distance of 1 cm.

### Procedure

Participants were instructed to retrieve a pallet from a shelf at 8 m height, lower it to the ground, and return it to the same shelf. After placing the forks on the ground, the task was repeated with a pallet at 11 m. These are segments of the total task. Participants then returned to the starting position, where the test leader adjusted the truck settings, before repeating the procedure. Prior to the task, all participants performed a maximum voluntary contraction (MVC) for the studied muscles. Participants were counterbalanced such that half began with the tilt setting activated and half without.

### Analysis

For the statistical analysis of the sEMG data, linear mixed-effects models (LMMs) were used to examine differences across tilt settings, heights, muscle types, and participants. The models

were based on mean muscle activation per segment, with tilt setting, height, and muscle type as fixed effects and participant included as a random effect. In addition, a thematic analysis was conducted on the qualitative interview data following the approach by Alvinius et al. (2023).

## Results

When using data normalised to MVC max and excluding the neck extensors, due to poor MVC normalization reliability and systematic signal saturation, a LMM revealed two significant effects ($p < 0.05$). Specifically, not using tilt resulted in higher overall muscle activation compared to using tilt ($\beta = 0.64814$, $p = 0.000253$), and the trapezius showed lower activation than the sternocleidomastoid ($\beta = -2.72459$, $p <$ 2e-16). Prior to normalizing the data, both the sternocleidomastoid and trapezius muscles exhibited lower activation than the neck extensors sternocleidomastoid: ($\beta = -25.581$, $p <$ 2e-16; trapezius: $\beta = -10.137$, $p =$ 1.69e-05). The interaction between no-tilt and trapezius activation approached significance ($0.05 < p < 0.10$), indicating a tendency toward higher trapezius activation when tilt was not used ($\beta = 6.452$, $p = 0.0505$).

The difference in muscle activation between work at 8 m and 11 m height was calculated by subtracting activation with tilt from the corresponding activation without tilt for each movement. Using the mean activation for each movement, the results showed that the effect of tilt differed across muscles. In 17 of the 36 total movement conditions, the use of tilt resulted in a larger difference in activation between the two heights.

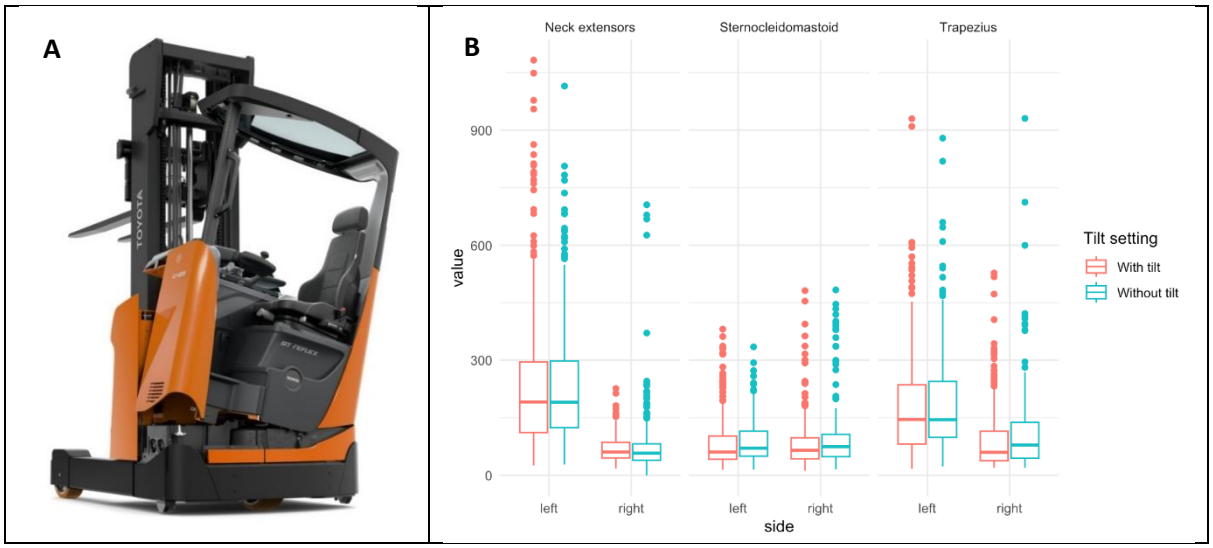


***Figure 1:*** *Toyota BT Reflex (A) and Max value of the 95% percentile of data, not normalized (B)*

## Thematic Analysis

Overall, the tilt function was positively received, frequently described as "better" and "more pleasant," with 12 participants expressing a preference for tilt unprompted. In addition, seven participants highlighted improved visibility, particularly noting a clearer view of the sides of

the pallet. The impact on the neck was a recurring theme, often mentioned without prompting. Participants generally perceived the tilt setting as reducing neck strain, and one participant linked the development of tilt cabins to reduced pain over time. Experiences of discomfort were common: five participants spontaneously mentioned neck pain, and when prompted, a total of 11 participants identified the neck as an area of discomfort. The shoulders and back were each mentioned by three participants. Some participants also noted that discomfort tends to occur early in a work period, either at the beginning of a career or when they return after a break and need to readjust. The main drawback of the tilt cabin, mentioned by more than one participant, was that it requires more space when lifting, which may pose challenges in narrow aisles.

**Discussion**

Although a statistically significant overall reduction in activation was observed with tilt, the effect was not consistent across muscles and heights. While slightly higher activation without tilt is observed in the maximum values. This finding is not consistent with previous work reporting a 20% reduction in neck extension with tilt (Cederqvist, 2000).

The comparison between 8 m and 11 m working heights suggests that tilt may lead to larger differences in activation between heights, rather than uniformly higher or lower activation. This may reflect improved visibility, enabling operators to engage more actively with tasks at greater heights, where perceived risk may be higher.

The thematic findings align with earlier research, as participants expressed a clear preference for the tilt setting and frequently reported improved visibility and reduced neck strain. Interestingly, these perceived benefits were more pronounced than the differences observed in the sEMG measures. This suggests that subjective experience and physiological workload may capture different aspects of operator performance. Improved visibility may enable operators to monitor loads more comfortably, reducing the need for awkward head and neck postures. Consequently, operators may perceive the task as easier and less strenuous despite only modest changes in muscle activation. This may explain why participants consistently reported improved comfort and reduced neck strain with tilt, whereas the sEMG results showed relatively small differences. The findings suggest that ergonomic benefits may arise from improved posture and visual access rather than substantial reductions in muscular workload.

## Conclusions

Tilted cabins did not produce a consistent overall reduction in muscle activation, although normalised data suggest a tendency toward lower activation with tilt. Instead of uniform effects, tilt was associated with greater variation in activation between working heights, indicating changes in task engagement rather than load reduction alone. Operators nevertheless strongly preferred tilt, reporting improved visibility and reduced neck strain. The mismatch between subjective and sEMG results suggests that perceived benefits may stem from improved posture and visual behaviour rather than directly lowered muscle activity. More broadly, the findings indicate that workplace design may influence operators' perception of the task and their engagement with visual information, highlighting the value of combining physiological and subjective measures when studying human performance in applied work settings.

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