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Analysis of the Working Posture of Ship Drivers in a Standing Position While Maneuvering When the Ship Enters and Exits the Port Using the *Rapid Entire Body Assessment* Method

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ABSTRACT

The static-standing work posture maintained by ship drivers during port entry and exit maneuvers has the potential to cause musculoskeletal disorders, yet ergonomic studies in the maritime context remain very limited compared to the land-based sector, particularly those combining posture risk assessment with facility redesign under vibration exposure. This study aims to analyze the working position of ship drivers while standing, assess the level of ergonomic hazards using the Rapid Entire Body Assessment (REBA) method, and develop a work facility improvement plan based on anthropometric data. A descriptive-quantitative approach with a case study design was applied to the MV. SM vessel, involving three drivers as respondents through total sampling. Data were collected through observation, interviews, Nordic Body Map (NBM) questionnaires, anthropometric measurements, and work posture documentation, then analyzed using the REBA assessment sheet and anthropometric data uniformity and percentile tests. The results showed an average NBM score of 72 (high category) with dominant complaints in the neck, shoulders, back, and lower limbs, while the initial REBA score of 4 (moderate risk, Action Level 2) was consistent across all respondents despite identical task and facility conditions, indicating that risk stemmed from equipment design rather than individual behavior. The adjustable steering design, based on the percentiles of standing elbow height (103.06–112.94 cm) and forward hand reach (67.71 cm), successfully reduced the REBA score to 2 (low risk, Action Level 1). This study contributes to the ergonomics literature by extending REBA-anthropometry integration into a static-standing, vibration-exposed maritime context not previously examined together, and by providing quantitatively validated evidence that an anthropometry-based engineering control can reduce musculoskeletal risk more durably than administrative interventions such as training. Practically, the resulting design offers shipping companies a concrete, low-cost, one-time facility intervention for improving wheelhouse ergonomics and crew safety.

INTRODUCTION

Working posture is a key determinant of a person's comfort, safety, and efficiency at work. Prolonged or unnatural postures cause uneven body weight distribution, accelerating fatigue and stressing specific muscles and joints, especially when activities require intense focus in uncomfortable body positions (Danur et al., 2022). Maritime transportation, particularly cargo ships, relies heavily on precise controls for safe and efficient navigation, and port entry and exit are operational stages that require extra vigilance (Williamson, 2023; Arwini & Juniastra, 2023). Studies based on the Automatic Identification System (AIS) show that the berthing and departure phases take considerable time, averaging approximately 77 and 33 minutes respectively (Wijaya & Nakamura, 2025), requiring drivers to maintain concentration and work posture for a relatively long time.

On the MV. SM, this activity is performed by three drivers who work in shifts standing in the wheelhouse while continuously gripping the steering wheel, their heads lowered to observe the panel and sailing route, and their feet providing the primary support for body balance against the ship's movements and engine vibrations. This condition limits the driver's ability to change body position, concentrating the workload on the neck, shoulders, back, waist, arms, wrists, calves, and feet a complaint pattern consistent with a systematic review of 804 high-speed boat operators, 74% of whom experienced chronic musculoskeletal pain, particularly in the lower back, neck, and head (Ullman et al., 2024)

Ergonomic principles hold that work systems should be adapted to human physical capability rather than the reverse, particularly where prolonged static postures are involved (Lorenzini et al., 2021; Colosio et al., 2021; Nur & Widharto, 2023; Bora et al., 2025). Maintaining a posture without movement variation increases static muscular load, reduces tissue blood flow, and can trigger musculoskeletal disorders (MSDs) if sustained over time (Aprianto et al., 2021; Sholeha & Sunaryo, 2022), with organizational consequences including increased absenteeism, higher medical and compensation costs, and reduced productivity (Aprianto et al., 2021) a burden that joint WHO/ILO estimates confirm at a global scale (Colosio et al., 2021).

The Rapid Entire Body Assessment (REBA) method was selected because it evaluates all relevant body segment neck, torso, legs, upper arms, forearms, and wrists together with load, grip quality, and activity type, making it well suited to prolonged static standing postures such as those of ship drivers (Handriawan et al., 2022; Pratiwi et al., 2021). Prior REBA applications report considerable variation depending on task context: Pratiwi et al. (2021) recorded a score of 6 among industrial workers; Handriawan et al. (2022) found scores of 2–7 across staining and finishing workstations; Sumiati et al. (2024) demonstrated that ergonomics training significantly reduced scores from 9.40 to 7.00 ($p = 0.006$); Yudiardi et al. (2021) reported very high risk in the squatting posture of floating bagan fishermen; and Akbar et al. (2023) found scores of 3–11 among bakery workers depending on task type. Collectively, these studies confirm REBA's relevance as an evaluative tool across diverse occupational settings.

However, a closer reading of this literature reveals a critical limitation: each of these studies is confined to shore-based, low-vibration environments in which posture is largely self-selected by the worker. None addresses a posture that is simultaneously static, externally constrained by fixed equipment geometry (here, the steering wheel and panel layout), and continuously perturbed by mechanical vibration the exact combination faced by ship drivers during berthing and departure. Maritime ergonomics research, meanwhile, has concentrated almost exclusively on navigation technology,

automation, and berthing systems (Miyauchi et al., 2022; Shimizu et al., 2022; Mwange et al., 2024), treating the human operator as a controller of the system rather than as a physical agent exposed to musculoskeletal risk within it. This leaves a specific and unaddressed research problem: how ship drivers' prolonged, vibration-exposed standing posture during port maneuvering contributes to musculoskeletal risk, and how the steering workstation itself rather than training or scheduling alone can be redesigned to mitigate that risk. To date, no published study has combined REBA-based posture risk assessment with anthropometry-driven redesign of a ship's steering facility, evaluated through a pre- and post-intervention compariso.

This gap matters for two reasons. Practically, shipping companies currently have no evidence-based reference for redesigning wheelhouse steering stations, leaving crews exposed to a modifiable risk factor that shore-based ergonomics guidelines do not address. Theoretically, the maritime ergonomics literature lacks a validated case demonstrating that REBA–anthropometry integration already established in manufacturing contexts transfers to a vibration-exposed, space-constrained maritime workstation, where standard anthropometric adjustment principles may not directly apply.

This study addresses that gap through two specific contributions. First, its theoretical contribution extends the application of REBA into a maritime work environment combining static standing posture with mechanical vibration exposure a risk-factor combination not previously examined together in the REBA literature thereby testing the boundary conditions under which REBA–anthropometry integration remains valid. Second, its practical contribution moves beyond risk identification to produce a concrete, anthropometrically-based adjustable steering design, validated through a before-and-after REBA comparison an iterative re-assessment approach rarely reported in maritime ergonomics studies. Unlike training-based interventions such as that of Sumiati et al. (2024), which depend on sustained worker compliance, the resulting design specifications constitute a low-cost, one-time facility-level intervention that shipping companies can implement directly to reduce musculoskeletal disorder risk among ship drivers.

Based on this problem and gap, the study has three specific objectives: (1) to characterize the standing work posture of ship drivers during port entry and exit maneuvers; (2) to quantify the associated ergonomic risk level using the REBA method; and (3) to develop an anthropometrically-based steering facility redesign and evaluate its effectiveness through pre- and post-intervention REBA scoring. The findings are expected to provide both empirical risk data for the maritime ergonomics literature and a practical, implementable design reference for shipping companies seeking to improve crew safety and comfort.

MATERIALS AND METHODS

The following is a broad outline of the research method flowchart used in this study.

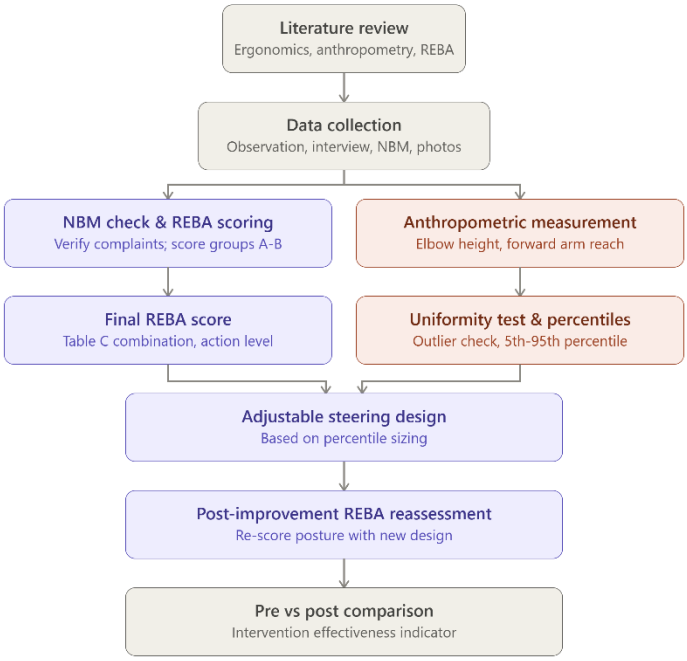


Figure 1. Research methodology flowchart

This research employed a descriptive-quantitative approach with a case study design on a single cargo ship, the MV. SM, operating on domestic shipping routes and anchored at the Port of PKG, Belawan. The research began on March 25, 2026. The case study approach was chosen because this research aimed to deeply explore the ergonomic conditions of a specific work group (ship drivers) whose population was limited, rather than to generalize statistically across a larger population.

The study subjects included three ship drivers (aged 35, 38, and 46) who took turns controlling the ship during port entry and exit. Subject selection was conducted using total sampling, considering that all drivers on the ship were included as respondents.

The research variables consisted of four main variables along with their operational definitions, namely: (1) the driver's body position while operating the steering wheel, measured through the angles of the neck, torso, legs, upper arms, forearms, and wrists according to the REBA assessment sheet; (2) body dimensions relevant to the driver's interaction with the work facility, including standing elbow height and forward arm reach, measured directly using a standard anthropometric measuring instrument; (3) the level of subjective complaints in 28 body segments, measured using the Nordic Body Map questionnaire on a scale of 1 (no pain) to 4 (very pain); and (4) recommendations for work facility design prepared based on the results of the REBA and anthropometric analysis, re-evaluated using the post-improvement REBA score as an indicator of success.

The data collection techniques were carried out through five methods, namely: (1) a literature study to obtain a conceptual framework for ergonomics, anthropometry, and REBA; (2) direct observation of driver activities in the driver's cabin; (3) interviews to explore subjective complaints and work constraints; (4) a Nordic Body Map questionnaire to map musculoskeletal complaints; and (5) documentation in the form of photographs of work postures that served as the basis for the REBA assessment. In

addition, a data analysis procedure was carried out in stages so that it could be duplicated by other researchers, as follows.

a) In the first stage, the results of the NBM questionnaire are summarized to verify the presence of musculoskeletal complaints as a basis for further posture analysis.
b) In the second stage, the REBA assessment is conducted by determining the scores for Group A (torso, neck, legs) and Group B (upper arms, forearms, wrists) based on the postural angles observed in visual documentation. These scores are then combined using REBA Tables A and B. The scores for both groups are then combined using Table C to obtain Score C. The Load/Force Score, Coupling Score, and Activity Score are added to obtain the final REBA Score, categorized using the five standard REBA Action Levels (Sumiati et al., 2024).
c) In the third stage, anthropometric data (elbow height and forward arm reach) were measured and tested through a data uniformity test using upper and lower control limits (mean ± 2 standard deviations) to ensure the data were free from outliers (Montgomery, 2013). This was followed by calculations of the 5th and 95th percentiles as the basis for determining the design size range.
d) In the fourth stage, the percentile results were used to develop a proposed adjustable steering design.
e) In the fifth stage, a reassessment of work postures was conducted using the REBA method after the proposed design was implemented to compare the risk levels before and after the improvements as an indicator of the intervention's effectiveness.

RESULTS AND DISCUSSIONS

Results

Observations showed that the three drivers worked in a standing position with both hands holding the steering wheel, their heads slightly lowered, and their torsos slightly leaning forward during the process of entering and exiting the port.

Table 1. Nordic Body Map Score Recapitulation

Respondent	Age	Total NBM Score	Risk Category
R1	35 years	64	Medium
R2	38 years	72	High
R3	46 years	80	High
Average		**72**	**High**

The Nordic Body Map complaint summary in Table 1 shows a total score of 64 (R1, moderate category), 72 (R2, high category), and 80 (R3, high category), with an average of 72 (high category). The highest complaints were concentrated in the neck, shoulders, back, waist, wrists, hands, calves, ankles, and soles of the feet.

Table 2. Recapitulation of REBA Scores Before and After Proposed Improvements

Components	Before Repair	After Repair
Group A Score (Trunk-Neck-Legs)	3	1
Group B Score (Upper Arm-Lower Arm-Wrist)	2	1
Group C Score	3	1
Activity Score	+1	+1
Final REBA Score	**4**	**2**
Risk Category / Action Level	**Medium / Level 2**	**Low / Level 1**

The REBA assessments for all three drivers yielded a consistent pattern, with Trunk scores of 2, Neck scores of 2, Legs scores of 1 (Group A score of 3); Upper Arm scores of 2, Lower Arm scores of 1, Wrist scores of 2 (Group B score of 2); Load/Force Score of 0 and Coupling Score of 0 (good grip on the steering wheel); Group C score of 3, plus Activity Score of 1 (static posture maintained for more than one minute), resulting in a final REBA Score of 4 for all three drivers, categorizing them as medium risk, Action Level 2, requiring corrective action.

Anthropometric analysis revealed that the drivers' standing elbow height ranged from 105–111 cm (mean 108 cm, SD = 3 cm) and forward arm reach ranged from 69–73 cm (mean 71 cm, SD = 2 cm), all within the upper-lower control limits and therefore considered consistent. The percentile calculation resulted in a standing elbow height range of P5–P95 of 103.06–112.94 cm and a forward hand reach of P5 of 67.71 cm, which is the basis for designing adjustable steering.

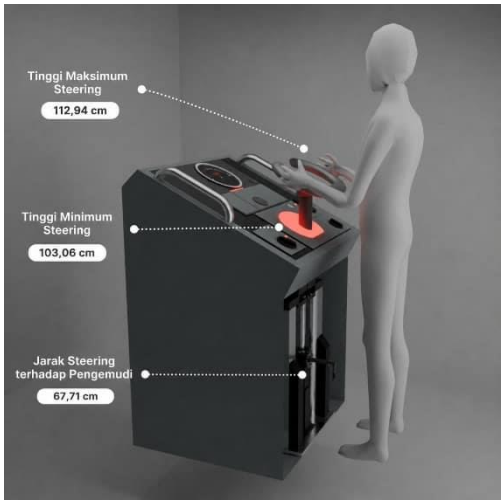


Figure 2. Adjustable steering design



Figure 3. Ship steering console / Autopilot console of the MV. SM

After the adjustable steering design suggestion was applied simulatively, the REBA re-assessment resulted in a score of Group A = 1, Group B = 1, Group C = 1, plus Activity Score = 1, so that the final REBA Score dropped to 2, low risk category, Action Level 1. This reduction in score from 4 to 2 was consistent across all respondents, indicating that adjusting the height and distance of the steering wheel to the driver's body dimensions successfully brought the neck, torso, and arms closer to a neutral posture.

Discussions

All three drivers obtained an identical pre-intervention REBA score of 4 (moderate risk), indicating that the ergonomic hazard in this activity is pervasive and stems from the design of the work equipment (a fixed steering wheel height) rather than from individual differences among drivers. This finding both aligns with and departs from Handriawan et al. (2022), who reported REBA scores ranging from 2–7 across workstations within a single manufacturing department. The similarity lies in the shared reliance on REBA to reveal variation in postural risk across a workforce; the difference is that Handriawan et al. attributed this variation primarily to task differences between stations, whereas in this study all three drivers performed an identical task at an identical facility yet still returned identical scores. This distinction is analytically important: it shifts the locus of risk from task variation the explanation favored in most prior REBA literature to facility design itself, a source of risk that individual-level or task-level analyses in previous studies were not positioned to isolate.

The REBA score of 4 obtained here is also lower than the scores reported by Pratiwi et al. (2021) (score of 6) and the pre-intervention score of Sumiati et al. (2024) (average 9.40). This gap is consistent with a key contextual difference: unlike the manufacturing and material-handling contexts in those studies, the ship drivers in this study carried no physical load and maintained good grip quality on the steering wheel (load/force score = 0, coupling score = 0). Even so, the persistence of a moderate-risk score of 4 despite these favorable load and grip conditions is itself a notable finding it indicates that prolonged static standing alone, sustained across maneuvers lasting tens of minutes (Wijaya & Nakamura, 2025), is sufficient to keep risk at a clinically meaningful

level. This nuance is not addressed in Pratiwi et al. or Sumiati et al., since both study populations were exposed to combined load-and-posture risk factors rather than posture risk in isolation underscoring that this study captures a distinct risk profile not previously documented in the REBA literature.

The Nordic Body Map results, showing a high complaint category (average score of 72), are consistent with Ullman et al.'s (2024) systematic review finding that 74% of speedboat operators experience chronic musculoskeletal pain concentrated in the lower back, neck, and head. Where Ullman et al.'s evidence is drawn from a secondary review across a large operator population, this study adds primary, facility-specific evidence by pairing subjective NBM complaints with observational REBA scores from the same three drivers. The convergence between these two independent measures subjective complaint and observed posture risk strengthens the internal validity of the conclusion beyond what either data source could support alone, a triangulation not present in Ullman et al.'s review-based synthesis.

The central contribution of this study, relative to prior REBA research, lies in testing an anthropometry-based engineering intervention through a quantitative pre–post REBA comparison, rather than stopping at risk identification. Akbar et al. (2023) and Yudiardi et al. (2021), for instance, documented REBA risk levels in bakery and fishing contexts but offered only qualitative recommendations standard operating procedures or stretching regimens without re-measuring whether those recommendations actually reduced risk. This study closes that gap: the REBA score dropped from 4 (moderate) to 2 (low) after implementing an anthropometrically-sized adjustable steering design, with no change to work methods or rest schedules. This also distinguishes the intervention type from Sumiati et al. (2024), whose comparable score reduction (9.40 to 7.00) was achieved through ergonomics training an administrative control that depends on sustained worker compliance. The reduction demonstrated here instead comes from an engineering control built into the workstation itself, which does not rely on ongoing behavioral adherence and is therefore likely to be more durable.

Taken together, these comparisons position this study distinctly within the REBA and maritime ergonomics literature. Compared with manufacturing-based REBA studies (Handriawan et al., 2022; Pratiwi et al., 2021), it demonstrates that moderate risk can arise from posture alone, in the absence of load or handling factors, and that facility design not task variation can be the dominant risk driver when task and equipment are held constant. Compared with intervention studies (Sumiati et al., 2024; Akbar et al., 2023; Yudiardi et al., 2021), it advances the field from qualitative recommendation or administrative control toward a quantitatively validated engineering control, evidenced by a measurable pre–post REBA reduction. Compared with maritime-specific evidence (Ullman et al., 2024), it moves beyond review-based prevalence data to primary, triangulated measurement within a specific vessel and workstation. Finally, it extends the transportation ergonomics framework of Jazilah et al. (2023), which has traditionally emphasized signage and procedural controls, by providing empirical evidence that physical redesign of the operator's workspace is a viable and measurable alternative one that shipping companies can implement as a one-time facility investment rather than a recurring training program.

CONCLUSION

The standing work posture of the three MV. SM drivers during port entry and exit maneuvers was characterized by a forward-leaning torso and a lowered neck while continuously gripping the steering wheel, resulting in an identical pre-intervention REBA

score of 4 (moderate risk, Action Level 2) across all respondents. Because all three drivers performed the same task on the same facility yet returned the same score, this risk is attributable primarily to the fixed steering wheel design rather than to individual differences in posture or behavior a finding that shifts the locus of risk from task variation, as emphasized in prior REBA studies such as Handriawan et al. (2022), to facility design itself. This was corroborated by an average Nordic Body Map score of 72 (high category), with complaints concentrated in the neck, shoulders, back, and lower limbs; the convergence between these subjective (NBM) and observational (REBA) results strengthens the validity of the conclusion that the drivers' working posture is genuinely ergonomically hazardous, consistent with the pattern reported by Ullman et al. (2024) among high-speed boat operators.

The proposed adjustable steering design, developed from the percentiles of standing elbow height (103.06–112.94 cm) and forward arm reach (67.71 cm), reduced the REBA score from 4 (moderate) to 2 (low risk, Action Level 1) consistently across all respondents, without any change to work methods or rest schedules. This result demonstrates that an anthropometry-based engineering control can achieve a measurable and durable risk reduction, distinguishing it from administrative interventions such as ergonomics training (e.g., Sumiati et al., 2024), which depend on sustained worker compliance, and from studies that stopped at qualitative recommendations without re-testing their effect (e.g., Akbar et al., 2023; Yudiardi et al., 2021). These findings confirm a specific contribution to the development of Industrial Engineering: empirical, quantitatively validated evidence that anthropometry-based engineering interventions can effectively lower musculoskeletal risk in a static-standing, vibration-exposed maritime work context an intervention pathway rarely tested through a pre–post REBA comparison in prior maritime ergonomics research, and one that extends the transportation ergonomics framework of Jazilah et al. (2023) beyond signage and procedural controls toward physical workstation redesign.

Based on these findings, shipping companies are advised to adopt anthropometrically-sized adjustable steering designs as a concrete, one-time facility investment to improve wheelhouse ergonomics, while ship captains are encouraged to stretch and vary body position periodically when operational conditions allow. As this study was limited to a single vessel and three respondents, future research should expand the number and types of vessels involved to strengthen the generalizability of these findings, and should incorporate objective physiological measurements, such as electromyography, to further verify the reduction in muscular load following the proposed intervention.

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