BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-016006
Article Type:	Research
Date Submitted by the Author:	16-Jan-2017
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Research methods
Keywords:	content validity, EPIDEMIOLOGY, fatigue, high-speed craft, repeated shock, whole-body vibration

Words in text	3225
Words in abstract	289
References	30
Table/Figures	5

A WEB-BASED QUESTIONNAIRE FOR LONGITUDINAL INVESTIGATION OF WORK EXPOSURE, MUSCULOSKELETAL PAIN AND PERFORMANCE IN HIGH-PERFORMANCE MARINE CRAFT POPULATIONS

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ABSTRACT

Objective: High-performance marine craft personnel (HPMCP) are regularly exposed to vibration and repeated shock (VRS) levels exceeding maximum limitations stated by international legislation. Whereas such exposure reportedly is detrimental to health and performance, the epidemiological data necessary to link these adverse effects causally to VRS is not available in the scientific literature, and no suitable tools for acquiring such data exist. This study therefore constructed a questionnaire for longitudinal investigations in HPMCP.

Methods: A consensus panel defined content domains, identified relevant items, and outlined a questionnaire. The relevance and simplicity of the questionnaire's content were then systematically assessed by expert raters in three consecutive stages, each followed by revisions. An item-level content validity index (I-CVI) was computed as the proportion of experts rating an item as relevant and simple, and a scale-level content validity index (S-CVI/Ave) as the average I-CVI across items. The thresholds for acceptable content validity were 0.78 and 0.90, respectively. Finally, a dynamic web-version of the questionnaire was constructed and pilot-tested over a one-month period during a marine exercise in a study population sample, while accelerometers simultaneously quantified VRS exposure.

Results: Content domains were defined as work exposure, musculoskeletal pain, and human performance, and items were selected to reflect these constructs. Ratings from nine experts yielded S-CVI/Ave of 0.97 and 1.00 for relevance and simplicity, respectively, and the pilot test suggested that responses were sensitive to change in acceleration and that the questionnaire, following some adjustments, was feasible for its intended purpose.

Conclusions: A dynamic web-based questionnaire for longitudinal survey of key variables in HPMCP was successfully constructed. Expert ratings supported that the questionnaire content

is relevant and simple, and the pilot test suggested that the questionnaire is feasible for longitudinal measurements in the study population.

Keywords: content validity, epidemiology, fatigue, high-speed craft, whole-body vibration.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The questionnaire was rigorously constructed with its content assessed by field experts and its feasibility pilot-tested in a study population sample.
- Questionnaire item responses were linked to co-measured craft acceleration and the results showed sensitivity to acceleration exposure.
- When combined with objective exposure data, this questionnaire enables quantification of the risk of musculoskeletal pain and impaired performance related to exposure to vibration and repeated shock.
- The questionnaire's content validity is limited by the proficiency of the authors and the expert raters, and the pilot test results by the small sample size.

INTRODUCTION

High-performance marine craft personnel (HPMCP) reportedly suffer from impaired health and performance related to their work at sea. Studies suggest that most of them have had work-related injuries which required medical care during their careers,[1] and that work-related fatigue commonly degrade their work ability.[2-4] Meanwhile, the risks related to the work environment at sea have been poorly investigated and could result from numerous interactive factors. One consistent element claimed to increase these risks is the exposure to vibration and repeated shocks (VRS). Although little is known regarding how far specific VRS components contribute to negative effects, prolonged exposure to whole-body vibration has been linked to musculoskeletal pain and impaired performance in other occupations.[5-8] This has resulted in the incorporation of recommendations for maximum daily occupational vibration exposure into international standards and legislation.[9-11]

Marine personnel are excluded from these statutory exposure limits, however, as compliance with them is infeasible given the available technology combined with the inherent demands of their occupation.[11] Those most concerned are likely HPMCP, as they regularly exceed the limits during typical working conditions, even when accounting for shock-mitigation systems.[12] It may therefore be that they risk musculoskeletal pain and impaired performance, especially considering their exposure to repeated shock in addition to whole-body vibration. However, the epidemiological data necessary to link causally the contribution of VRS exposure to adverse effects is absent in the scientific literature, and no suitable tools for acquiring such data exist.

Our group recently developed a comprehensive questionnaire that samples information on marine personnel and their working environment, and enables the prevalence of adverse health and performance effects and their association with work exposure to be quantified.[13]

However, to isolate the causal effects of VRS exposure on health and performance, a complementary, more succinct, instrument with higher resolution is required. Several environmental factors other than VRS likely contribute to adverse effects in marine personnel and needing to be partialled out.[14-16] In addition, it is important to select appropriate sampling periods, as sea conditions vary greatly and recall bias decreases measured variable precision.[17 18] Also, the longitudinal design necessary for such investigations is prone to data attrition,[19] necessitating feasible data collection tools. This study therefore constructed a web-based questionnaire tailored for longitudinal investigation of work exposure, health and performance in HPMCP.

METHODS

Design

In three steps, a web-based questionnaire in English was developed, validated and pilot-tested in collaboration between the Royal Institute of Technology, Karolinska Institutet, the Swedish Coast Guard and the Norwegian Special Operations Command. Content domains were defined, items were generated, and the questionnaire was outlined by a consensus panel. The questionnaire draft was then assessed by experts in an iterative validation procedure, and the validated questionnaire pilot-tested in a study population sample.

Consensus panel and expert raters

The present authors constituted the consensus panel: two engineers with theoretical and empirical experience in naval architecture, specialists in high-speed marine craft; and two physiotherapists with experience in epidemiologic investigations, biomechanical studies and questionnaire development.

In accordance with previous recommendations based on their knowledge of the content domains, research methodology and statistical analysis,[20] ten independent experts from Sweden, Norway and England enrolled for participation: four women and six men (Table 1).

[TABLE 1: ABOUT HERE]

Development procedure

The questionnaire content was concentrated on key aspects in the previously identified domains of work exposure, health and performance[13] to provide a more comprehensive coverage of these features. The literature was reviewed to isolate suitable parameters for domain quantification, and items were selected to reflect central features of the measured constructs while balancing content across domains. Items were evaluated based on their analytical value and the questionnaire was designed to be linked to accelerometer data for objective VRS quantification. Sampling periods were selected to capture accurately the measured variables and to reduce recall bias. To optimize the questionnaire for longitudinal measurements, the balance between data quality and respondent burden was carefully considered, with items selected and web-mechanisms implemented to minimize the total number of items. In addition, with the propensity of longitudinal designs for data attrition, optional items were added to facilitate missingness assumptions necessary for result inferences.[19] Finally, a control item inquiring about music preference at sea was included in the first questionnaire draft to evaluate experts' attention to their task.

Validation procedure

In three consecutive stages, experts assessed individual items by rating their relevance and simplicity on two separate 4-point Likert scales: 'not relevant/not simple', 'somewhat relevant/somewhat simple', 'quite relevant/quite simple' and 'very relevant/very simple'. Ratings were dichotomized so that the two lowest and the two highest options represented

non-relevant/non-simple and relevant/simple, respectively.[21 22] In addition, experts could comment on individual items and the questionnaire as a whole, and were invited to provide general feedback on the questionnaire and its length. Taking into consideration the experts' feedback, items were revised, added or discarded by the consensus panel between each validation stage. Prior to the third stage, the questionnaire was professionally proofread and implemented online, and the experts were given access to the online version for evaluation in its intended environment.

An item-level content validity index (I-CVI) was computed for relevance and simplicity as the proportion of experts rating an item as relevant or simple, respectively,[21 22] with 0.78 selected as the threshold for an acceptable I-CVI.[22 23] A scale-level content validity index was calculated as the average across items' I-CVI (S-CVI/Ave) and as the proportion of items which all experts rated as relevant or simple (S-CVI/UA), with selected thresholds of 0.90 and 0.80 for an acceptable S-CVI/Ave and S-CVI/UA, respectively.[21 22] A more detailed description of the validation procedure is provided elsewhere.[13]

Pilot test

To assess the questionnaire's feasibility and to preliminarily evaluate item properties, it was pilot-tested in a convenience sample of eight Norwegian Special Operations Command officers during a marine exercise where high-speed planing craft were regularly operated. The participants were men aged 28–40 years, with 1–20 years of work experience at sea, who regularly manoeuvred and navigated marine craft.

The questionnaire was completed on the respondents' personal cell phones, and participants were instructed to complete one section on exposure and performance at the end of each work shift and one section on health once weekly over a one-month period. In addition, their craft were instrumented to collect the acceleration time-history data at sea to

enable data comparison. Following the pilot test period, the subjects provided verbal feedback on the questionnaire.

RESULTS

An overview of the questionnaire construction process is given in Figure 1 and the final questionnaire in the supplementary materials.

Development

The work exposure domain focused on the crew's operational environment and contained items related to work: duration, environment and task. One item identified craft ID to permit linkage between questionnaire data and objective data, and a ride-quality item was included as a measure of ride roughness,[24] useful both as an indicator of VRS exposure when objective data is unavailable and for identifying acceleration features affecting the perception of ride roughness. Items regarding body posture and crew gear, environmental conditions, mission and work task were included for their biomechanical relevance,[4] reported influence on impaired health and performance[14-16] and relevance to mental and physical demands, respectively.

The health domain focused on work-related musculoskeletal pain, it being previously associated with VRS exposure and one of the main areas of concern among HPMCP.[1] Pain occurrence was considered the main variable and auxiliary items were included to describe its characteristics. In line with established recommendations for chronic pain measurement selected auxiliary items inquired about pain location, pain intensity, pain frequency and physical functioning impairment.[25 26] Pain location was mapped with a previously developed 16-zone figure to maintain compatibility with the baseline questionnaire[13] and additional sub-items related to the specific locations. Pain intensity was assessed with a standard formulation

used to reflect the average pain magnitude over the past week and measured on an 11-point numeric rating scale.[25] Pain frequency was quantified by providing a daily schedule split between day and night, allowing for a rapid selection of pain occurrence, and simultaneously permitting quantification of pain patterns and association of pain and exposure. Physical function impairments were considered in relation to reduction in work ability, since this parameter involves both practical and financial ramifications. Finally, one item inquiring about perceived cause of pain was included for its descriptive value.

Performance was mainly measured indirectly via fatigue symptoms, as they have been associated with impaired performance.[2 3 27 28] Fatigue is a subjective experience constituting of several dimensions.[28 29] Mental fatigue was targeted since it closely reflects performance impairments in common work tasks among HPMCP. A composite summary score derived from 4–5 items encompassing different aspects of fatigue was considered the most suitable method to capture the latent fatigue construct.[28 29] Selected fatigue items were inspired by previous questionnaires,[28 30] and adapted to the study population. In addition to the fatigue summary score items, two items for self-rated human and craft performance were included.

Work exposure and performance items targeted the previous work shift to capture acute effects, which presumably are reversed with rest, and to reduce recall bias. In contrast, musculoskeletal pain items targeted the previous week, as prolonged VRS exposure conceivably causes overload injuries, engendering residual effects that increase the likelihood of pain events over time. Also, the recollection of discrete pain events likely is less prone to bias.

To maintain the respondent burden at an acceptable level, the option to deactivate redundant items (e.g., the duration-at-sea item when time at sea is registered elsewhere), a dynamic mechanism which automatically skips redundant items, and only closed-ended response options (i.e., predetermined responses selected from a list) were incorporated. With

all items active, the dynamic mechanism reduced daily items related to work exposure and performance from 19 to seven when respondents had not worked at sea, and limited the maximum number of weekly items related to pain to 14 by leading to auxiliary pain items inquiring about the worst and the least painful areas when more than three pain locations were selected.

To reduce bias related to missing data, one optional item was added with response options defined to support different missing data assumptions.[19] Refusal to respond to an item was managed by incorporating a hidden response option (i.e., 'I do not want to answer this question'), which appeared only when respondents attempted to skip an item. Selection of this option strongly suggests that missingness is related to the item itself.

[FIGURE 1: ABOUT HERE]

Validation

The first questionnaire draft contained 28 items (excluding the control item which all experts rated as non-relevant), of which 13 were related to work exposure, six to pain, seven to performance and two to missing data. Ratings by 10 experts revealed acceptable I-CVI for simplicity and relevance of 26 items, thereby exceeding the threshold of 0.90 for an acceptable S-CVI/Ave in the first stage. However, 90 item-specific expert comments at this stage prompted further item refinement. Based on this feedback, 18 items were revised, two were added to enhance the fatigue summary score, and one on mission status was discarded as inapplicable to subgroups of the study population.

The second questionnaire draft of 29 items was rated by nine experts, as one expert discontinued the process. Whereas 28 items met the cut-off for an acceptable I-CVI, 45 expert comments again indicated opportunities for further improvements. Accordingly, 12 items

were modified and three were removed: one related to shock mitigation at sea since it was considered redundant, and two related to the fatigue summary score since they were found confusing or redundant.

The third and final 26-item questionnaire draft was also rated by nine experts, with 25 items having an acceptable I-CVI for both relevance and simplicity, amounting to an S-CVI/Ave of 0.97 and 1.00, and an S-CVI/UA of 0.85 and 0.96 for relevance and simplicity, respectively. Eight of nine experts commented on the overall questionnaire. All responded that the questionnaire was good to very good; four suggested that it was of good length while four felt it was slightly too long. The 'headache' item (item 12) failed to meet acceptable I-CVI for relevance, was rejected by three of nine experts, but was nonetheless retained for further assessment because of its potential value as a fatigue indicator. Table 2 details the results of the validation process.

[TABLE 2: ABOUT HERE]

Pilot test

The pilot test suggested that the completion time for both questionnaire parts combined was approximately 10 minutes. Of eight subjects, seven participated in the daily part about work exposure and performance and five in the weekly part about musculoskeletal pain. Over the one-month period, these respondents completed each part 2–15 and 1–5 times, respectively.

Data obtained indicated that the questionnaire's psychometric properties were acceptable. Responses had either uniform or unimodal distributions across item categories. The 'Other' option available for some items was never selected, and no participants elected to avoid any item response. Exposure-related items registered similar ratings for subjects on the same craft,

and there were no contradictory ratings. Of 14 occasions, 7–10 ratings each for ride quality, sea conditions, wind conditions, noise level and temperature, and 3–5 ratings each of sea spray and visibility were identical between subjects, and ratings differed by at most two categories.

The 'ride-quality' item showed sensitivity to acceleration exposure (Figure 2), and the fatigue summary score items showed sensitivity to ride quality (Figure 3). However, because the response distribution in the fatigue items suggested that a potential floor effect might be present, which could be detrimental to fatigue discrimination, some changes were made to increase sensitivity. The 'memory' item, excluded in the validation process based on expert comments – and which nevertheless met the criterion for an acceptable I-CVI – was re-integrated for further evaluation. Moreover, the 'concentration', 'decision' and 'memory' items were revised to accommodate a bipolar response structure (i.e., 'Very high' to 'Very low'), and an additional response category was added to both the 'headache' and 'tiredness' items. Final modifications were also implemented with respect to the musculoskeletal pain items. Feedback from the subjects revealed that they lacked a response option for absence of pain while under pain relief medication; the response structure of the 'pain event' item was therefore revised to accommodate this. Finally, the 'perceived pain cause' item was removed to reduce the respondent burden.

[FIGURE 2: ABOUT HERE]

[FIGURE 3: ABOUT HERE]

DISCUSSION

This study developed, validated and pilot-tested a questionnaire for longitudinal investigation of work exposure, musculoskeletal pain and performance in high-performance marine craft personnel (HPMCP). Ratings from nine experts computed to an S-CVI/Ave of

0.97 and 1.00 for relevance and simplicity, respectively, supported excellent content validity, and the pilot test suggested that the questionnaire, following some adjustments, was feasible for its intended purpose.

The expert ratings supported that the questionnaire content was both relevant with respect to the intended content domains and simple to understand. In the first validation stage the S-CVI/Ave already exceeded the commonly used threshold of 0.90;[21 22] however, expert item-level disagreement and the multiplicity of comments indicated that further improvements were possible. Items were noticeably refined in subsequent stages, as reflected by the increase in S-CVI/UA, which improved from 0.64 and 0.50 in the first stage to 0.85 and 0.96 in the final stage for relevance and simplicity, respectively, thereby meeting the acceptability criterion of 0.80 for both.[21 22]

Although our content validity indices were exceptionally high in comparison both to our baseline questionnaire and to reported results of other questionnaires,[13 21] certain adjustments were necessary to finalize the questionnaire. Item 12 (‘headache’) failed to meet an acceptable I-CVI for relevance but was nonetheless retained, as expert comments suggested that this was due to a lack of understanding of its intended purpose as a fatigue summary score item. This decision was supported by the pilot-test results which indicated that it was sensitive to ride roughness. In addition, a potential floor effect detected by inspecting the distribution in fatigue-related items, prompted the return of item 15 (‘memory’) and the changes in the response structure of all fatigue-related items.

While the results from both the validation process and the pilot test supported the adequacy of the questionnaire in quantifying the content domains, it could involve a considerable respondent burden as the final version contains up to 30 items. Upon initial review, the response rate suggested that there was a problem with the feasibility of the questionnaire for longitudinal measurements. The secrecy of the group investigated prevented determination of

the exact response rate and attached causes (e.g., respondents' work schedules were classified); however, respondent feedback revealed that they were not allowed to use their cell phones during a one-week exercise and that two intended subjects did not participate in the marine exercise and therefore dropped out. In addition, Norwegian occupational regulations demand an average two-day rest per week. Accounting for these factors, we approximated a response rate of >85% for three subjects and 10–40% for the three remaining subjects in the daily questionnaire section, and 100% for one subject, 50% for three subjects and 0–25% for two subjects in the weekly questionnaire section. Thus, in this pilot study, half the respondents had an acceptable response rate for the daily section, but only one of six for the weekly section. Respondent feedback suggested that the low response rate for the weekly section was related to the division of the questionnaire into two parts, and both sections were therefore incorporated into a single web-questionnaire. Noteworthy is that in this pilot test, we maximized the respondent burden both in sampling frequency, once following each work shift, and in total questionnaire items. Decrease of either of these two aspects would likely increase questionnaire feasibility for longitudinal investigation.

This study has some limitations. Whereas a large number of experts were included in the questionnaire validation to provide a suitable breadth of knowledge across content domains and to lessen the risk of chance agreement,[22] its validity is limited by the proficiency of the expert raters and the consensus panel. Likewise, the results of this pilot test, conducted in a sample chosen to represent HPMCP subjected to the most intense VRS exposure, are limited by the small sample size. With respect to the questionnaire content, performance was indirectly measured via fatigue, as performance and fatigue have previously been associated[2 3 27 28] and as performance is hard to capture with self-reported data. To know how far the questionnaire items actually measure performance it is, however, necessary to link them to objective performance indicators.

In addition to the construction of the present questionnaire, knowledge acquired from this study resulted in modifications to the previously developed baseline questionnaire: the item order was altered so that prioritized items were placed before other items, fatigue summary score items were altered to improve their sensitivity, and the wording of pain-related items was revised. The updated version is available in the supplementary materials. In conjunction with objective exposure data, the two questionnaires provide a means to quantify the extent of musculoskeletal pain and performance impairments in HPMCP, and to link the contribution of VRS exposure causally to these effects. However, for accurate inferences, the questionnaires' psychometric properties should be further evaluated.

CONCLUSIONS

A dynamic web-based questionnaire for longitudinal investigation of work exposure, musculoskeletal pain and performance in high-performance marine craft populations was successfully constructed. Ratings from nine experts supported that the questionnaire content was relevant and simple. A pilot test suggested that items were sensitive to change in content domains, and that the questionnaire, following some adjustments, was suited for its purpose in the study population.

ACKNOWLEDGEMENTS

We thank the expert raters for their feedback, and the Norwegian Special Operations Command officers for their participation in the pilot test. We also thank Lea Constan for excellent feedback on the manuscript, Jan Ivar Kåsin from the Norwegian Institute of Aviation Medicine for connecting us to experts and pilot test subjects from the study population, and Stefan Andersson from the Swedish Coast Guard for providing experts from the study population.

CONTRIBUTIONS

KG is leading the research program of which this study is a part. All authors conceived and designed the study, and constituted the consensus panel. RLM and MPdA outlined the questionnaire and refined it in accordance with the experts' feedback. RLM implemented the questionnaire online and drafted the manuscript, and MPdA, KG and BOA reviewed and contributed to the manuscript's development. All authors read and approved the final manuscript.

FUNDING

The Gösta Lundeqvist Foundation for Ship Research (Gösta Lundeqvists stiftelse för skeppsteknisk forskning) and the Swedish Maritime Administration (Sjöfartsverket).

COMPETING INTERESTS

None declared.

ETHICS APPROVAL

Ethics approval was obtained from the Regional Committee for Medical Research Ethics (Dnr. 2015/576-31), Stockholm, Sweden. All participants received study information and signed an informed consent.

DATA-SHARING STATEMENT

No additional data available.

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FIGURE CAPTIONS

Figure 1. Flow chart of the questionnaire construction process.

Figure 2. Sampled acceleration relative to self-reported ride quality for the only two subjects with complete data.

Figure 3. The four top graphs show fatigue-related ratings per ride quality category and the bottom graph shows the number of fatigue symptoms defined as ratings other than 'No' for each observation. Figures are based on 58 observations from repeated measurements in seven subjects.

TABLES

Table 1. Expert characteristics.

Expert	Profession	Area of expertise
1	Special operations command officer	HSC operations, target population.
2	Special operations command officer	HSC operations, target population.
3	Coastguard officer	HSC operations, target population.
4	Coastguard officer	HSC operations, target population.
5	Engineer, researcher	HSC human factors engineering.
6	Engineer, researcher	HSC human factors engineering.
7	Physician, researcher	Medicine, human biomechanics, content validity.
8	Physiotherapist, researcher	Epidemiology, questionnaire development, musculoskeletal pain.
9	Physiotherapist, researcher	Questionnaire development, musculoskeletal pain.
10	Physiotherapist	Occupation therapist in the study population.

HSC, high-speed craft

Table 2. Expert ratings across the three validation stages.

		Relevance						Simplicity					
		Stage 1 (*n*=10)		Stage 2 (*n*=9)		Stage 3 (*n*=9)		Stage 1 (*n*=10)		Stage 2 (*n*=9)		Stage 3 (*n*=9)	
Domain	**Item**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**
Work exposure	Hours at sea	4–4	1.00	3–4	1.00	4–4	1.00	1–4	0.90	3–4	1.00	4–4	1.00
	Ride quality	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Craft ID	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	4–4	1.00	4–4	1.00
	Craft experience	3–4	1.00	3–4	1.00	3–4	1.00	2–4	0.90	4–4	1.00	3–4	1.00
	Mission	2–4	0.90	4–4	1.00	4–4	1.00	2–4	0.90	3–4	1.00	4–4	1.00
	Task	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	4–4	1.00	4–4	1.00
	Open deck	1–4	0.70	4–4	1.00	4–4	1.00	2–4	0.60	3–4	1.00	4–4	1.00
	Equipment	2–4	0.90	4–4	1.00	3–4	1.00	2–4	0.90	3–4	1.00	4–4	1.00
	Body posture	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	2–4	0.89	3–4	1.00
	After dark	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00
	Environmental conditions	1–4	1.00	3–4	1.00	4–4	1.00	3–4	0.90	2–4	0.89	3–4	1.00
	Shock mitigation*	3–4	1.00	2–4	0.89	–	–	2–4	0.90	4–4	1.00	–	–
	Craft ergonomics	3–4	1.00	2–4	0.89	4–4	1.00	1–4	0.80	1–4	0.89	4–4	1.00
	(Music preference)	1–2	0.00	–	–	–	–	1–4	0.60	–	–	–	–
Pain	Pain event	2–4	0.90	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Pain location	3–4	1.00	4–4	1.00	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00
	Pain frequency	3–4	1.00	4–4	1.00	3–4	1.00	2–4	0.90	2–4	0.78	3–4	1.00
	Pain intensity	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00

	Pain consequences	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Perceived pain cause	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
Performance	Headache	2–4	0.90	2–4	0.78	2–4	0.67	3–4	1.00	4–4	1.00	3–4	1.00
	Concentration	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Decisions[+]	–	–	3–4	1.00	2–4	0.89			3–4	1.00	3–4	1.00
	Memory[+,*]	–	–	2–4	0.78	–	–	–	–	3–4	1.00	–	–
	Effort of thinking*	1–4	0.80	1–4	0.67	–	–	2–4	0.70	3–4	1.00	–	–
	Tiredness	2–4	0.70	2–4	0.89	3–4	1.00	2–4	0.80	4–4	1.00	4–4	1.00
	Human performance	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Craft performance	2–4	0.90	3–4	1.00	2–4	0.78	2–4	0.80	3–4	1.00	2–4	0.89
	Mission status*	2–4	0.80	–	–	–	–	2–4	0.90	–	–	–	–
Missing data	Reason for non-response	2–4	0.90	4–4	1.00	2–4	0.89	3–4	1.00	4–4	1.00	4–4	1.00
	Perceived pain cause	3–4	1.00	3–4	1.00	3–4	1.00	2–4	0.80	3–4	1.00	4–4	1.00
S–CVI/Ave			0.91		0.96		0.97		0.91		0.98		1.00
S–CVI/UA			0.64		0.79		0.85		0.50		0.86		0.96

I-CVI, item-level content validity index: proportion of expert ratings higher than two. S-CVI/Ave, scale-level content validity index average: mean I-CVI across items. S-CVI/UA, scale-level content validity index universal agreement: proportion of items which all experts rated higher than two. Thresholds for acceptable I-CVI, S-CVI/Ave, and S-CVI/UA were 0.78, 0.90, and 0.80, respectively. *, discarded item. [+], added item. (), control item.

1. DEVELOPMENT PHASE

Target domains

- *Literature review*
- *Consensus panel discussion*

Work exposure

- *Duration*
- *Environment*
- *Work tasks*

Pain

- *Location*
- *Severity*
- *Frequency*
- *Consequences*

Performance

- *Fatigue*
- *Human performance*
- *Craft performance*

Questionnaire outlining

- *Analysis-driven*
- *Iterative draft-review process*

Item pool

- *Avaliable items*
- *Modified avaliable items*
- *New items created*

Final questionnaire draft

- *Consensus panel approval*

2. VALIDATION PHASE

Stage 1

First questionnaire draft (28 items)

Expert ratings (*n*=10)

- *2 non-relevant items*
- *2 non-simple items*
- *90 comments*

Consensus panel

- *18 items revised*
- *2 items added*
- *1 item discarded*

Stage 2

Second questionnaire draft (29 items)

Expert ratings (*n*=9)

- *1 non-relevant item*
- *0 non-simple items*
- *44 comments*

Consensus panel

- *12 items revised*
- *3 item discarded*

Stage 3

Third questionnaire draft (26 items)

Expert ratings (*n*=9)

- *1 non-relevant items*
- *0 non-simple items*
- *15 comments*

Consensus panel

- *Final questionnaire*

1 expert dropped out

Language review
Web implementation

3. PILOT TEST

Pre-test considerations

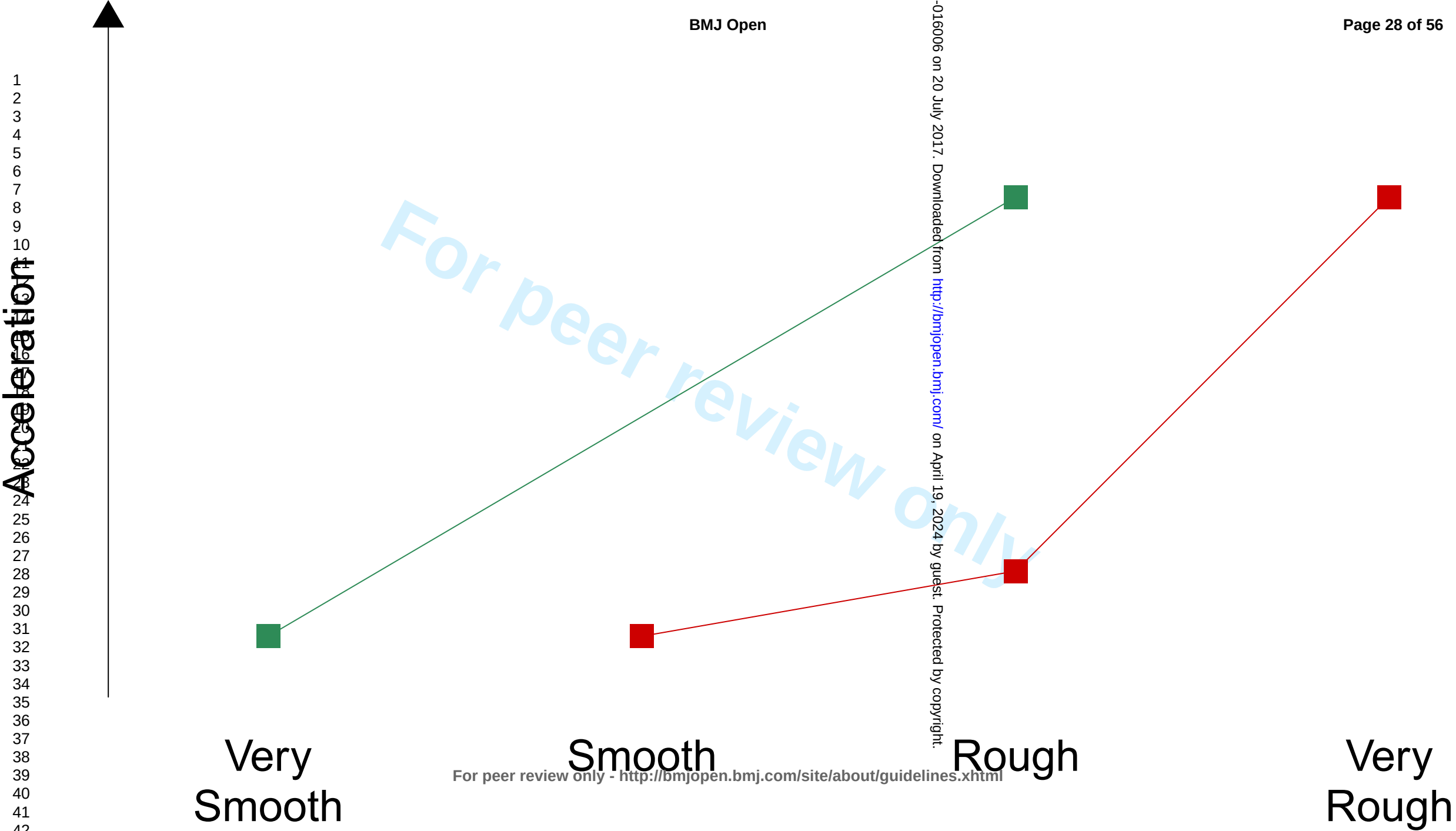
- *Debugging*
- *Web-tests*
- *Expert feedback*

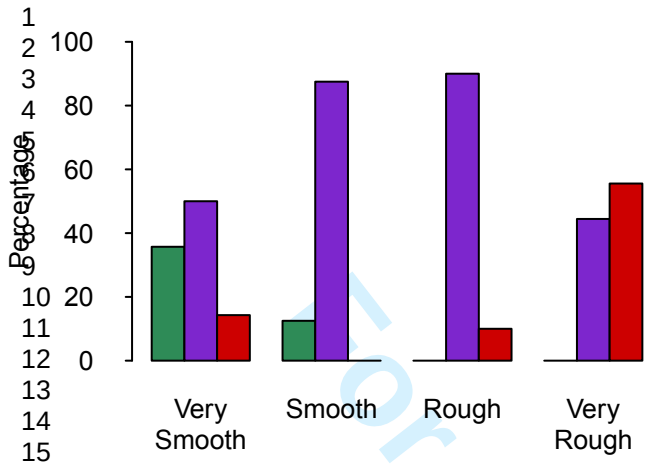
Data collection

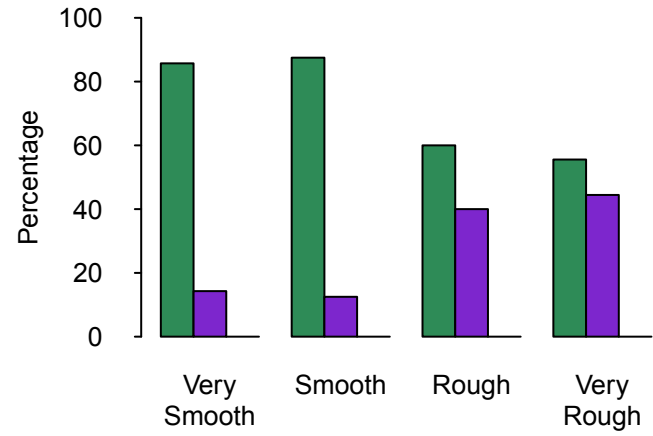
- *8 subjects*
- *Repeated measurements*
- *Questionnaire data*
- *Accelerometer data*

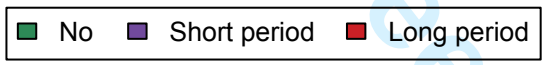
Evaluation

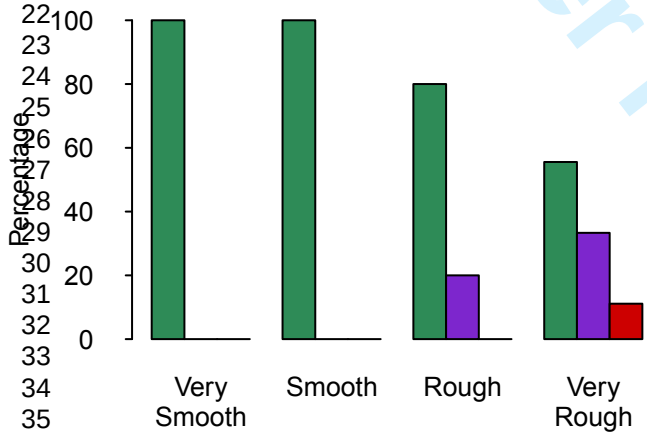
- *Visual analysis*
- *Descriptive statistics*

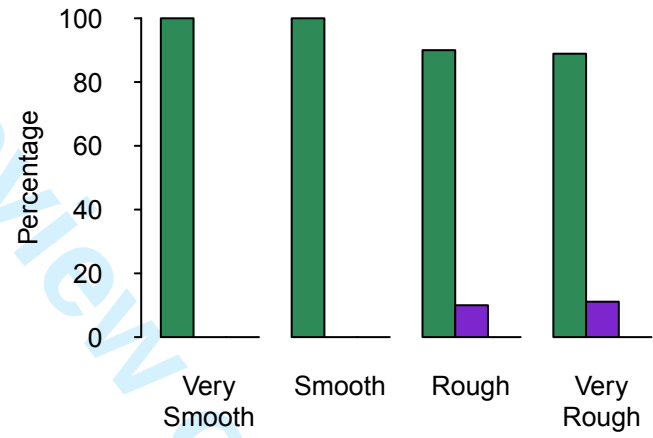












Questionnaire on Work Exposure, Musculoskeletal Pain, and Performance among High-Performance Marine Craft Personnel

This survey investigates work exposure, musculoskeletal pain, and performance among high-performance marine craft personnel, and your participation is important as you have relevant skills. In total, it contains about 25 questions which take roughly 10 minutes to complete.

Your responses are *strictly confidential*, will be processed *anonymously*, and are used only for this investigation.

Please read the questions carefully and answer honestly.

Thank you for your time**.**

EXPOSURE AND PERFORMANCE MODULE (ADMINISTERED DAILY)

The following questions concern your last work shift (i.e., the one you just completed or are about to complete just now).

1. **How many hours of this work shift did you spend at sea (i.e., away from the pier)?**
   Please include time inactive (e.g., breaks, sleep at work, or standby).

   [DROPDOWN LIST] hours

---

2. **How would you rate ride quality aboard the craft during this work shift?***
   Ride quality refers to the comfort of the boat ride.

   ☐ Very smooth *(good comfort with no or very few bumps)*
   ☐ Smooth
   ☐ Rough
   ☐ Very rough (considerable *discomfort or strain as a result of sea state, vessel speed, or both)*

---

* Condition: >0 hours selected in item 1.

3. **Please select the craft you worked onboard during this shift:***
   If you worked onboard more than one craft, select them in the order you were on them, starting with '1' for the first craft.

   ☐ Craft ID 1**
   ☐ …
   ☐ Other

---

* Condition: >0 hours selected in item 1. ** Craft ID 1 used as an example.

4. **How familiar are you with *Craft ID 1***?***

   ☐ I have *a lot* (months) of experience working aboard that particular craft
   ☐ I have *some* (weeks) experience working aboard that particular craft
   ☐ I have *no or almost no* (days) experience working aboard that particular craft

---

* Condition: Craft ID selected in item 3. ** Craft ID 1 used as an example.

5. **Please select the options that best describe your work at sea during this shift:***
   Multiple options possible.

   ☐ Patrol
   ☐ Search and Rescue
   ☐ Transport *(person or cargo)*
   ☐ Firefighting
   ☐ Law enforcement or other offensive mission
   ☐ Other

---

* Condition: >0 hours selected in item 1.

6. What was your *main* task at sea during this work shift?*

☐ Craft driving
☐ Craft navigation
☐ Work on deck
☐ Work on engine or other machinery
☐ Active duty onboard *(e.g., lookout or equipment operator)*
☐ Passenger
☐ Other

* Condition: >0 hours selected in item 1.

7. Did you perform your *main* task on open deck during this work shift?*

☐ No
☐ Yes

* Condition: >0 hours selected in item 1.

8. What equipment were you wearing at sea during this work shift?*
Multiple options possible.

☐ Helmet
☐ Vest *(e.g., body armour)*
☐ Weapon or equipment belt
☐ Survival suit *(i.e., immersion suit or dry suit)*
☐ Night vision goggles
☐ Other
☐ None

* Condition: >0 hours selected in item 1.

9. Which body posture best describes your work at sea during this shift?*

☐ Sitting regardless of sea condition
☐ Standing regardless of sea condition
☐ About half the time sitting and half the time standing
☐ Mainly sitting, but standing in rough sea conditions
☐ Mainly standing, but sitting in rough sea conditions

* Condition: >0 hours selected in item 1.

10. How much time did you spend at sea after dark during this work shift?*

☐ 0%
☐ 25%
☐ 50%
☐ 75%
☐ 100%

* Condition: >0 hours selected in item 1.

11. Please select the option that best describes this work shift's…*

…sea conditions?	☐ Calm *(Like a mirror.)* ☐ Smooth *(Ripples or wavelets without or with few with caps.)* ☐ Moderate *(Small waves with breaking crests. Fairly frequent white caps.)* ☐ Rough *(Long waves and very frequent white foam crests. Some sea spray.)* ☐ High *(High waves whose crests sometimes roll over. Dense white foam. Large amounts of sea spray.)*
…wind conditions?**	☐ Calm ☐ Light breeze ☐ Moderate breeze ☐ Strong breeze ☐ Gale
…sea spray?**	☐ Very little ☐ Some ☐ Moderate ☐ Much ☐ Very much
…visibility? *Refer to the visibility that affected your work the most (e.g., inside boat: low light, instrument back light etc; outside boat: fog, sunshine reflection etc).*	☐ Excellent ☐ Very good ☐ Good ☐ Acceptable ☐ Poor
…noise level?	☐ Quiet ☐ Faint ☐ Moderate ☐ Uncomfortable ☐ Intolerable
…temperature? *Refer to the temperature that affected you the most.*	☐ Uncomfortably hot ☐ Hot ☐ Comfortable ☐ Cold ☐ Uncomfortably cold

* Condition: >0 hours selected in item 1. ** Condition: 'Yes' selected in item 7.

12. Did you suffer from headache during this work shift?

☐ No, not at all
☐ Yes, for a short period
☐ Yes, for a long period
☐ Yes, for nearly the entire work shift

---

13. How would you rate your ability to concentrate during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

14. How would you rate your ability to make decisions during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

15. How would you rate your ability to remember things during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

16. Do you feel tired right now?
'Right now' refers to the end of the past work shift

☐ No, I feel completely rested
☐ Yes, a little tired
☐ Yes, very tired
☐ Yes, exhausted

---

17. How would you rate your working performance during this shift?

☐ Very good
☐ Good
☐ Moderate
☐ Poor
☐ Very poor

---

18. How would you rate the craft's performance with respect to this shift's activities?*

☐ Very good *(craft performed well in the conditions)*
☐ Good
☐ Moderate
☐ Poor
☐ Very poor *(craft was unable to cope with the conditions)*

* Condition: >0 hours selected in item 1.

19. How suitable were the craft ergonomics (e.g., controls, equipment, and/or interior of the sea vessel) for this work shift's missions?*

☐ Perfectly suitable
☐ Good, but there is room for improvement
☐ Not so good, they reduced my work performance
☐ Poorly suitable

* Condition: >0 hours in selected item 1.

PAIN MODULE (ADMINISTERED WEEKLY)

The following questions concern the past 7 days.

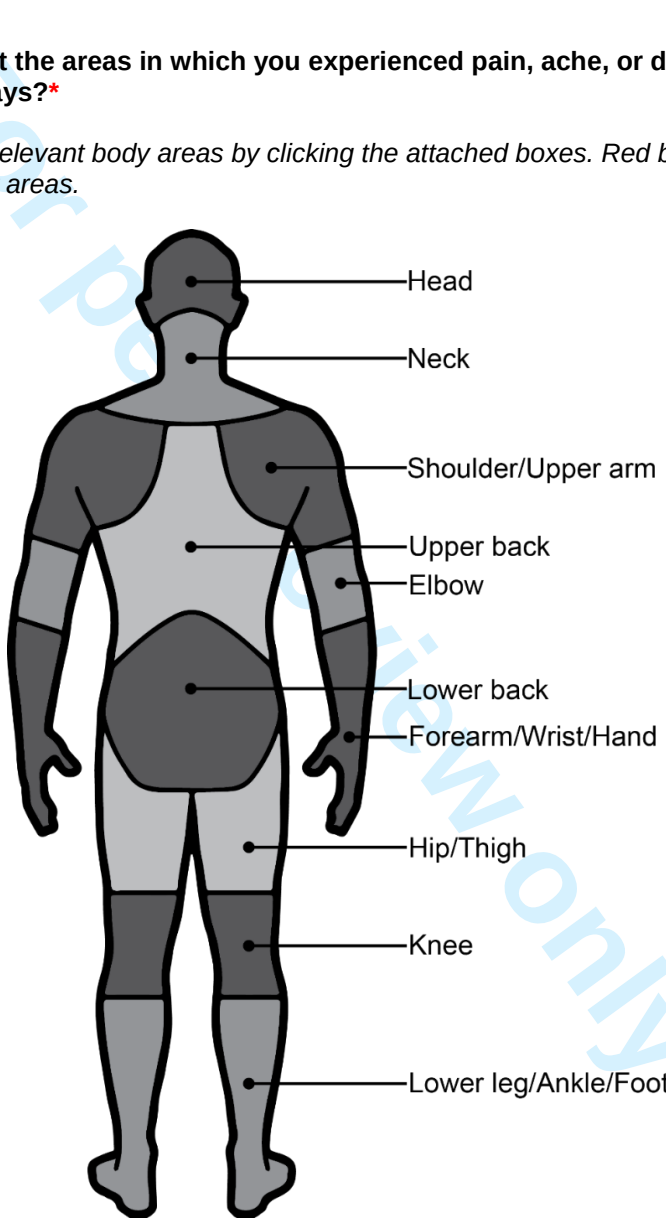
20. Have you experienced pain, ache, or discomfort during the past 7 days?

☐ No, and I was *not* taking pain relief medication
☐ No, but I was taking pain relief medication
☐ Yes

---

21. Please select the areas in which you experienced pain, ache, or discomfort during the past 7 days?*

Please mark relevant body areas by clicking the attached boxes. Red boxes indicate selected body areas.



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* Condition: 'Yes' selected in item 20.

Please select all periods during which you experienced *neck* pain, ache, or discomfort during the past 7 days:***

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day-time							
Night-time							

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

Please rate the intensity that best describes your average *neck* pain, ache, or discomfort during the past 7 days:***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No pain										Worst possible pain

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

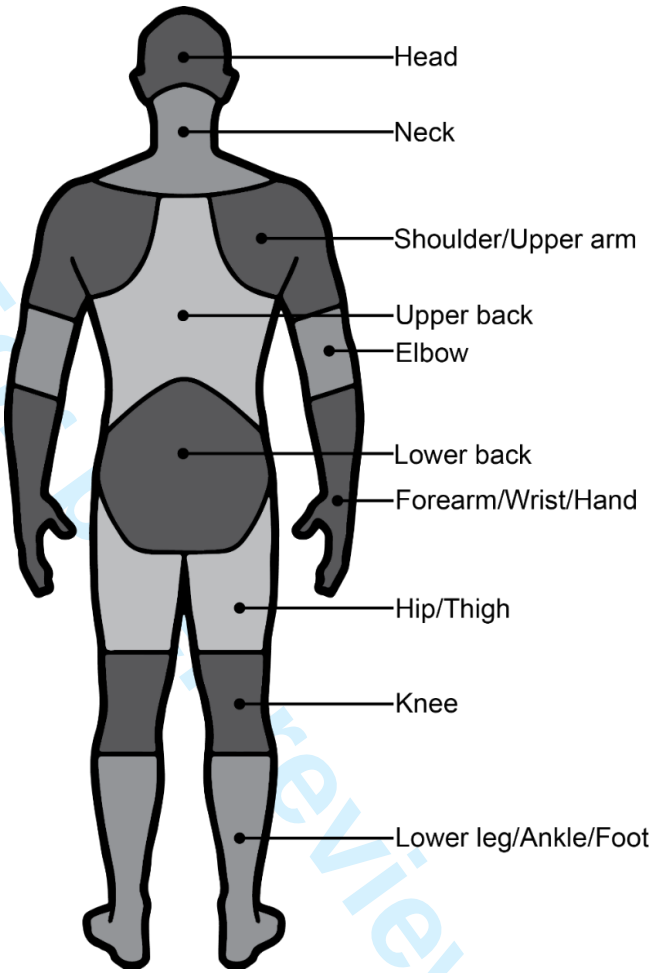
Did the *neck* pain, ache, or discomfort during the past 7 days reduce your work ability?**

☐ No, not at all
☐ Yes, somewhat
☐ Yes, a lot (e.g., it required me to temporarily change work task)
☐ Yes, it required sick leave

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

Please select the area in which you experienced *the worst* pain, ache, or discomfort during the past 7 days?***

Please mark the body area by clicking the attached box. A red box indicate a selected body area.



* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Please select all periods during which you experienced pain, ache, or discomfort *in the area with the worst pain* during the past 7 days:***

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day-time							
Night-time							

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Please rate the intensity that best describes your average pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 days:***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No pain										Worst possible pain

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Did the pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 days reduce your work ability?***

☐ No, not at all
☐ Yes, somewhat
☐ Yes, a lot (e.g., it required me to temporarily change work task)
☐ Yes, it required sick leave

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

MISSING DATA MODULE (ADMINISTERED FOLLOWING RETURN AFTER FAILURE TO RESPOND)

1. **Please select the reason for not completing the questionnaire *last week**:**

☐ I did not have the possibility to do it
☐ I forgot
☐ I was not at work
☐ I was too tired
☐ I was on sick leave related to pain, ache, or discomfort
☐ Other

---

* Last week used as an example

Questionnaire on Working Conditions, Performance, and Health among High-Performance Marine Craft Personnel

This survey investigates working conditions and health status among high-performance seaborne personnel, and your participation is important regardless of your work tasks. In total, the survey contains about 40 questions covering the areas of demography, lifestyle, work, and health, which take roughly 30 minutes to complete.

Your responses are *strictly confidential*, will be processed *anonymously*, and are used only for this investigation.

Please read the questions carefully and answer honestly.

Thank you for your time**.**

1. What year were you born?

[DROPDOWN LIST]

---

2. What is your height?

[DROPDOWN LIST] cm

---

3. What is your weight?

[DROPDOWN LIST] kg

---

4. What is your sex?

☐ Female
☐ Male
☐ Other

---

5. What is your highest *completed* level of education?

☐ Primary school
(the first stage of school, usually between the ages of 5 to 11 years; or equivalent education for adults)

☐ Secondary school
(the stage after primary school and before higher education, usually between the ages of 11 and 18 years; or equivalent education for adults)

☐ Vocational school
(education which qualifies for a profession, but not a university education)

☐ University degree
(academic degree completed in university, college, or equivalent)

---

6. Do you consume tobacco daily?

☐ No
☐ Yes, I smoke (e.g., cigarettes or pipe)
☐ Yes, I use a non-smokeable tobacco product (e.g., snuff or chewing tobacco)

---

7. Have you previously consumed tobacco daily for longer than 6 months?*

☐ No
☐ Yes, cigarettes or another smokeable tobacco product
☐ Yes, a non-smokeable tobacco product (e.g., snuff or chewing tobacco)

---

* Condition: 'No' selected in item 6.

8. How often do you have a drink containing at least 3% alcohol?

☐ Never
☐ Once per month or less
☐ 2–4 times per month
☐ 2–3 times per week
☐ 4 times per week or more

---

9. How many alcoholic drinks (as defined below) do you have on a typical day when you drink any alcohol?*

☐ 1 or 2
☐ 3 or 4
☐ 5 or 6
☐ 7, 8 or 9
☐ 10 or more

---

* Condition: 'Never' NOT selected in item 8.

10. How many hours *per week* do you typically train for muscle strength (e.g., weight-lifting or other kinds of resistance training)?

[DROPDOWN LIST] hours

---

11. How many hours *per week* are you physically active at least at moderate intensity due to exercise, transport, daily activities or work-related tasks?
Physical activity of a moderate intensity results in a slightly faster heart rate and breathing frequency, e.g., running, bicycling, brisk walking, or scuba-diving in high water current.

[DROPDOWN LIST] hours

---

12. How many hours *per day* do you typically spend sitting down…

…in free time (off work)?	**…at work: on land (including transport to and from work)?**	**…at work: at sea?**
[DROPDOWN LIST] hours	[DROPDOWN LIST] hours	[DROPDOWN LIST] hours

---

13. Do you feel excessively sleepy during daytime…

…in free time (off work)?	**…at work?**
☐ Never or less than once per month	☐ Never or less than once per month
☐ Less than once per week	☐ Less than once per week
☐ A few times per week	☐ A few times per week
☐ Daily or almost daily	☐ Daily or almost daily

---

14. How satisfied are you with your social situation during your free time (off work)?
Social situation: relation to family, friends and acquaintances; and satisfaction with economic situation and accommodation.

☐ Perfectly satisfied
☐ Satisfied
☐ Slightly unsatisfied
☐ Not satisfied at all

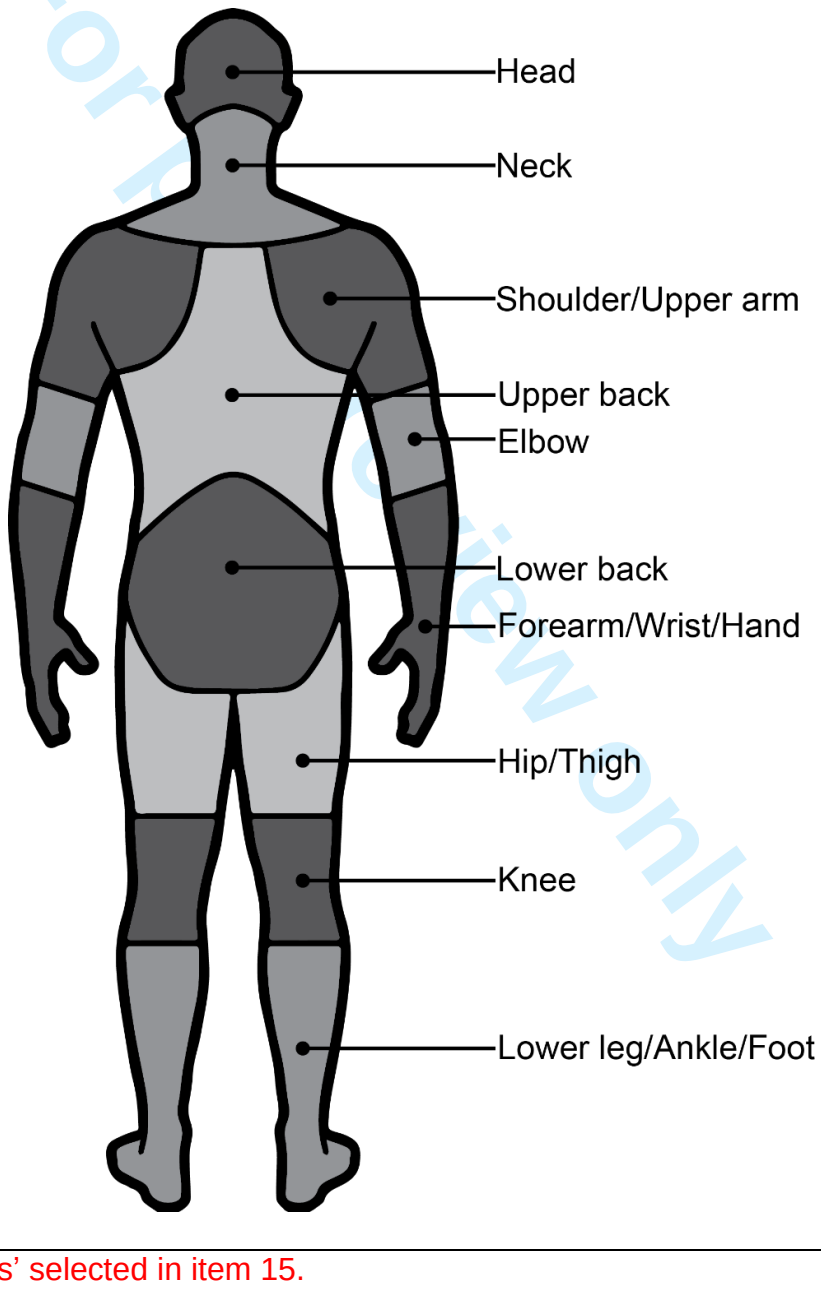
---

15. Have you experienced pain, ache, or discomfort during the past 6 months?

☐ No
☐ Yes

---

16. Please select the body areas in which you have experienced pain, ache, or discomfort during the past 6 months:*
Please mark relevant body areas by clicking the attached boxes. A red box indicate a selected body area.



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* Condition: 'Yes' selected in item 15.

During the past 6 months, have you experienced *neck* pain, ache, or discomfort on several occasions, *separated* by time periods with no pain?***

☐ No, on one occasion only
☐ No, I have had pain on a daily basis during the previous 6 months
☐ Yes, I have experienced pain on several occasions

* Condition: Body area selected in item 16 AND ≤3 body areas selected in total. ** Neck used as an example.

Did the *neck* pain, ache, or discomfort during the past 6 months….***

…result in you seeking health care?	…require treatment?	…reduce your ability to practice any activities outside work?	…reduce your work ability?
☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes, to some extent ☐ Yes, to a large extent ☐ Yes, it caused me to quit the activity permanently	☐ No ☐ Yes, to some extent ☐ Yes, to a large extent ☐ Yes, it required sick leave ☐ Yes, it caused me to change work tasks permanently

* Condition: Body area selected in item 16 AND ≤3 body areas selected in total. ** Neck used as an example.

Was the *neck* pain, ache, or discomfort during the past 6 months related to an acute injury acquired at work?***

☐ No
☐ Yes
☐ I do not know

* Condition: Body area selected in item 16 AND ≤3 body areas selected in total. ** Neck used as an example.

Have you experienced *neck* pain, ache, or discomfort during the past 7 days?***

☐ No
☐ Yes

* Condition: Body area selected in item 16 AND ≤3 body areas selected in total. ** Neck used as an example.

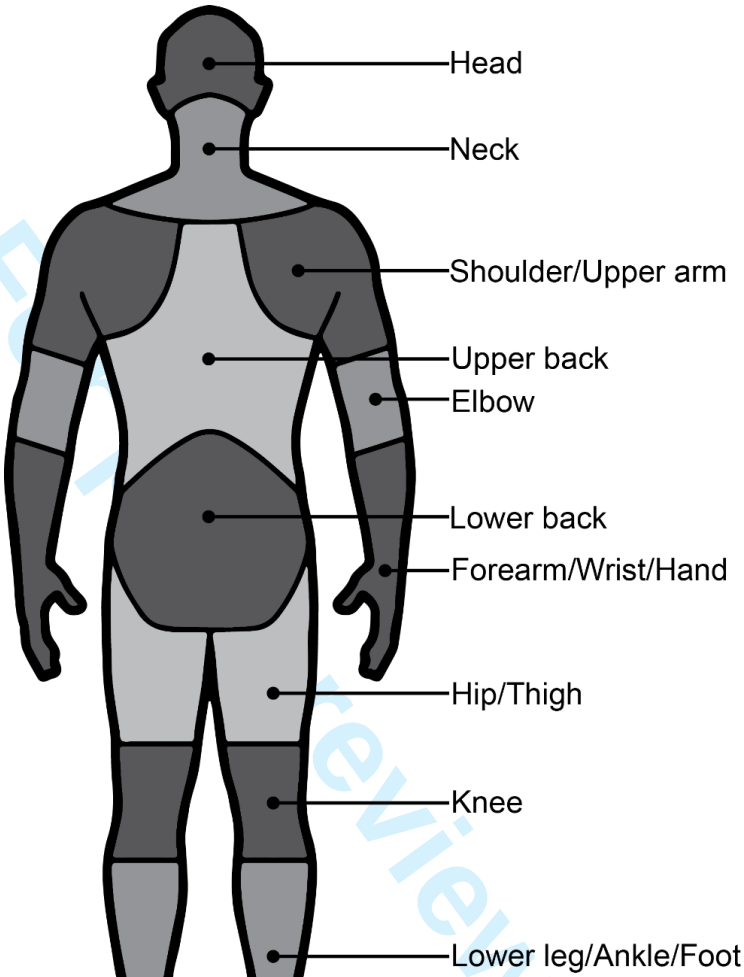
Please rate the intensity that best describes your *average neck* pain, ache, or discomfort during the past 7 Days:***

0	1	2	3	4	5	6	7	8	9	10
☐ No pain	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Worst possible pain

* Condition: Body area selected in item 16 AND ≤3 body areas selected in total. ** Neck used as an example.

Please select the area in which you experienced *the worst* pain, ache, or discomfort during the past 6 months?***

Please mark the body area by clicking the attached box. A red box indicate a selected body area.



* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

During the past 6 months, have you experienced pain, ache, or discomfort *in the area with the worst* *pain* on several occasions, *separated* by time periods with no pain?***

☐ No, on one occasion only
☐ No, I have had pain on a daily basis during the previous 6 months
☐ Yes, I have experienced pain on several occasions

* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

Did the pain, ache, or discomfort *in the area with the worst* *pain* during the past 6 months….***

…result in you seeking health care?	**…require treatment?**	**…reduce your ability to practice any activities outside work?**	**…reduce your work ability?**
☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes, to some extent ☐ Yes, to a large extent ☐ Yes, it caused me to quit the activity permanently	☐ No ☐ Yes, to some extent ☐ Yes, to a large extent ☐ Yes, it required sick leave ☐ Yes, it caused me to change work tasks permanently

* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

Was the pain, ache, or discomfort *in the area with the worst* *pain* during the past 6 months related to an acute injury acquired at work?***

☐ No
☐ Yes
☐ I do not know

* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

Have you experienced pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 days?***

☐ No
☐ Yes

* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

Please rate the intensity that best describes your *average* pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 Days:***

0	1	2	3	4	5	6	7	8	9	10
☐ No pain	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Worst possible pain

* Condition: ≥4 body areas selected in item 16. ** An identical item also provided for the least painful area.

17. Are you affected by any of the following conditions? Please select the options most appropriate to you:

		Is it kept under control by an ongoing treatment? *E.g., by medication, passive aids, or physiotherapy.**
Remaining effects from previous injury to muscle, bone, or other body tissue? *E.g., fractures, extensive burns, or muscle tears.*	☐ No ☐ Yes	☐ No ☐ Yes
Disorders in back, joints, muscles, or skeleton? *E.g., osteoarthritis, rheumatoid arthritis, or chronic muscle pain.*	☐ No ☐ Yes	☐ No ☐ Yes
Cardiovascular disease? *E.g., high blood pressure, angina pectoris, or heart attack.*	☐ No ☐ Yes	☐ No ☐ Yes
Respiratory disease? *E.g., asthma, chronic bronchitis, or emphysema.*	☐ No ☐ Yes	☐ No ☐ Yes
Mental health problems? *E.g., depression or anxiety.*	☐ No ☐ Yes	☐ No ☐ Yes
Neurological disease? *E.g., multiple sclerosis or residual effects from strokes.*	☐ No ☐ Yes	☐ No ☐ Yes
Disorders in stomach or digestive system? *E.g., heartburn, gastric ulcer, liver, kidney or intestinal disease.*	☐ No ☐ Yes	☐ No ☐ Yes
Cancer or other malignant tumor?	☐ No ☐ Yes	☐ No ☐ Yes
Blood disease? *E.g., anemia, leukopenia, or thrombocytopenia.*	☐ No ☐ Yes	☐ No ☐ Yes
Disabling birth defects? *E.g., abnormal limbs or heart defects.*	☐ No ☐ Yes	☐ No ☐ Yes
Other disease, disability, or allergy? *E.g., diabetes or nut allergy.*	☐ No ☐ Yes	☐ No ☐ Yes

* Condition: 'Yes' selected for the condition.

18. How do you perceive your general health?

☐ Excellent
☐ Very good
☐ Good
☐ Acceptable
☐ Poor

---

19. How many hours do you typically work in month (i.e., a 4-week period), including time off *active* duty (e.g., breaks, sleep at work, or standby)?

[DROPDOWN LIST] hours

---

20. How are your work shifts distributed in a typical working month (i.e., a 4-week period)?

☐ Day shifts
☐ Night shifts
☐ Day and night shifts mixed (including continuous multiday shifts)

---

21. Do you work at sea?

☐ No, and I have never worked at sea
☐ No, but I have previously worked at sea
☐ Yes

---

22. How many hours do you typically work at sea in a month (i.e., 4-week period), including time off *active* duty (e.g., breaks, sleep at work, or standby)?*

[DROPDOWN LIST] hours

---

* Condition: 'Yes' OR 'No, but I have previously worked at sea' selected in item 21.

23. How many years have you had a job were you partly worked at sea?*

[DROPDOWN LIST] years

---

* Condition: 'Yes' OR 'No, but I have previously worked at sea' selected in item 21.

24. Please select your typical work tasks (several options are possible):

☐ Administration/office work
☐ Craft driving
☐ Craft navigation
☐ Work on deck
☐ Diving
☐ Work in engine room
☐ Other

---

25. How much of your time working at sea have you worked onboard each of the vessel types below…*

…during the past 6 months?

Displacement vessels *(large in size and relatively low speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

Semi-displacement vessels *(medium in size and relatively high speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

Planing craft *(small high speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

…during your total employment at sea?

Displacement vessels *(large in size and relatively low speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

Semi-displacement vessels *(medium in size and relatively high speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

Planing craft *(small high speed vessels)*

☐ 0%
☐ 1 – 30 %
☐ 31 – 60%
☐ 61 – 100%

* Condition: 'Yes' OR 'No, but I have previously worked at sea' selected in item 21.

26. How often do you experience rough working conditions onboard the craft categorized below?*
Rough working conditions: discomfort or strain as a result of sea state, vessel speed, or both.

Displacement Vessels (large in size and relatively low speed vessels):

☐ Never
☐ Almost never
☐ Sometimes
☐ Practically always

Semi-Displacement Vessels (medium in size and relatively high speed vessels)

☐ Never
☐ Almost never
☐ Sometimes
☐ Practically always

Planing Craft (small high speed vessels)

☐ Never
☐ Almost never
☐ Sometimes
☐ Practically always

* Condition: >0% selected for vessel type during the past 6 months in item 25.

27. What is the *most common* reason for you to reduce speed when operating vessels in rough sea conditions?*

☐ Crew safety (to prevent human injury)
☐ Vessel safety (to prevent structural failure, e.g., hull)
☐ Crew performance (to maintain decent work conditions onboard)
☐ Vessel performance (to prevent equipment and machinery failure)
☐ Other

* Condition: 'craft driving' selected in item 24.

28. Have you used any suspension systems during work at sea in the past 6 months? *
Common suspension systems include suspension seats, suspended hulls, and suspended cockpits

☐ Never
☐ Almost never
☐ Sometimes
☐ Practically always
☐ I do not know

* Condition: 'Yes' OR 'No, but I have previously worked at sea' selected in item 21.

29. How suitable were the ergonomics (e.g., controls, equipment, and/or interior of the sea vessel) of the craft you have mainly worked in during the past 6 months?*

☐ Perfectly suitable
☐ Good, but there is room for improvement
☐ Not so good, they reduced my work performance
☐ Poorly suitable

* Condition: 'Yes' OR 'No, but I have previously worked at sea' selected in item 21.

30. Please select the options most appropriate to you:

Do you suffer from headache at work?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily
Do you find it hard to concentrate during work?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily
Do you find it hard to make decisions during work?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily
Do you find it hard to remember things during work?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily
Do you feel tired at the end of your work shifts?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily
Do you suffer from motion sickness during work?	☐ Never or less than once per month ☐ Less than once per week ☐ A few times per week ☐ Daily or almost daily

31. Please select the options most accurate to you:

Does your job require you to work fast?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your job require you to work intensively?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your job demand too much effort?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Do you have enough time for all your work tasks?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your work often involve conflicting demands?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often

32. Please select the options most accurate to you:

Do you have opportunities to learn new things in your work?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your job require a high level of skill or expertise?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your job require creativity?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Does your job require you to do the same tasks over and over again?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Do you have the possibility to decide *how* to do your work?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often
Are you able to decide *what* to do at work?	☐ Never or almost never ☐ Seldom ☐ Sometimes ☐ Often

33. Please select the options most accurate to you:

My work environment is quiet and pleasant	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree
We have strong unity at my work place	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree
My co-workers support me	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree
My co-workers understand if I have a "bad" day	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree
I get along with my supervisors at work	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree
I get along with my co-workers	☐ Strongly agree ☐ Mildly agree ☐ Mildly disagree ☐ Strongly disagree

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Thank you for your participation!

BMJ Open

Construction of a web-based questionnaire for longitudinal investigation of work exposure, musculoskeletal pain and performance impairments in high-performance marine craft populations

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-016006.R1
Article Type:	Research
Date Submitted by the Author:	24-May-2017
Complete List of Authors:	Lo Martire, Riccardo; KTH Royal Institute of Technology, Department of Aeronautical and Vehicle Engineering, Centre for Naval Architecture; Karolinska Institutet, Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy de Alwis, Manudul; Kungliga Tekniska Hogskolan Skolan for teknikvetenskap, Department of Aeronautical and Vehicle Engineering Centre for Naval Architecture Äng, Björn; Hogskolan Dalarna, School of Education, Health and Social Studies; Centrum for Klinisk Forskning Dalarna Garme, Karl; KTH Royal Institute of Technology, School of Engineering Sciences, Department of Aeronautical and Vehicle Engineering, Centre for Naval Architecture
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Research methods
Keywords:	content validity, EPIDEMIOLOGY, fatigue, high-speed craft, repeated shock, whole-body vibration

Words in text	3396
Words in abstract	293
References	38
Table/Figures	5

CONSTRUCTION OF A WEB-BASED QUESTIONNAIRE FOR LONGITUDINAL INVESTIGATION OF WORK EXPOSURE, MUSCULOSKELETAL PAIN AND PERFORMANCE IMPAIRMENTS IN HIGH-PERFORMANCE MARINE CRAFT POPULATIONS

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ABSTRACT

Objective: High-performance marine craft personnel (HPMCP) are regularly exposed to vibration and repeated shock (VRS) levels exceeding maximum limitations stated by international legislation. Whereas such exposure reportedly is detrimental to health and performance, the epidemiological data necessary to link these adverse effects causally to VRS is not available in the scientific literature, and no suitable tools for acquiring such data exist. This study therefore constructed a questionnaire for longitudinal investigations in HPMCP.

Methods: A consensus panel defined content domains, identified relevant items, and outlined a questionnaire. The relevance and simplicity of the questionnaire's content were then systematically assessed by expert raters in three consecutive stages, each followed by revisions. An item-level content validity index (I-CVI) was computed as the proportion of experts rating an item as relevant and simple, and a scale-level content validity index (S-CVI/Ave) as the average I-CVI across items. The thresholds for acceptable content validity were 0.78 and 0.90, respectively. Finally, a dynamic web-version of the questionnaire was constructed and pilot-tested over a one-month period during a marine exercise in a study population sample of eight subjects, while accelerometers simultaneously quantified VRS exposure.

Results: Content domains were defined as work exposure, musculoskeletal pain, and human performance, and items were selected to reflect these constructs. Ratings from nine experts yielded S-CVI/Ave of 0.97 and 1.00 for relevance and simplicity, respectively, and the pilot test suggested that responses were sensitive to change in acceleration and that the questionnaire, following some adjustments, was feasible for its intended purpose.

Conclusions: A dynamic web-based questionnaire for longitudinal survey of key variables in HPMCP was constructed. Expert ratings supported that the questionnaire content is relevant,

simple and sufficiently comprehensive, and the pilot test suggested that the questionnaire is feasible for longitudinal measurements in the study population.

Keywords: content validity, epidemiology, fatigue, high-speed craft, whole-body vibration.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The questionnaire was rigorously constructed with its content assessed by field experts and its feasibility pilot-tested in a study population sample.
- Questionnaire item responses were linked to co-measured craft acceleration and the results showed sensitivity to acceleration exposure.
- When combined with objective exposure data, this questionnaire enables quantification of the risk of musculoskeletal pain and impaired performance related to exposure to vibration and repeated shock.
- The questionnaire's content validity is limited by the proficiency of the authors and the expert raters, and the pilot test results by the small sample size.

INTRODUCTION

High-performance marine craft personnel (HPMCP) such as coast guards, navy or maritime pilots, reportedly suffer from impaired health and performance related to their work at sea. Studies suggest that most of them have had musculoskeletal pain the preceding year,[1] work-related injuries which required medical care during their careers,[2] and that work-related fatigue commonly degraded their work ability.[3-5] Meanwhile, the risks related to the work environment at sea have been poorly investigated and could result from numerous interactive factors. One consistent element claimed to increase these risks is the exposure to vibration and repeated shocks (VRS). Although little is known regarding how far specific VRS components contribute to negative effects, prolonged exposure to whole-body vibration has been linked to musculoskeletal pain and impaired performance in other occupations.[6-11] This has resulted in the incorporation of recommendations for maximum daily occupational vibration exposure into international standards and legislation.[12-14]

Marine personnel are excluded from these statutory exposure limits, however, as compliance with them is infeasible given the available technology combined with the inherent demands of their occupation.[14] Those most concerned are likely HPMCP, as they regularly exceed the limits during typical working conditions, even when accounting for shock-mitigation systems.[15 16] They also experience some of the highest levels of vibration when compared to that of land borne personnel with an elevated vibration-related risk for pain.[6 17] HPMCP may therefore risk musculoskeletal pain and impaired performance, especially considering their exposure to repeated shock in addition to whole-body vibration. However, the epidemiological data necessary to link causally the contribution of VRS exposure to adverse effects is absent in the scientific literature, and no suitable tools for acquiring such data exist.

Our group recently developed a comprehensive questionnaire that samples information on marine personnel and their working environment, and enables the prevalence of adverse health and performance effects and their association with work exposure to be quantified.[18] However, to isolate the causal effects of VRS exposure on health and performance, a complementary, more succinct, instrument with higher resolution is required. Several environmental factors other than VRS likely contribute to adverse effects in marine personnel and needing to be partialled out.[19-21] In addition, it is important to select appropriate sampling periods, as sea conditions vary greatly and recall bias decreases measured variable precision.[22-24] Also, the longitudinal design necessary for such investigations is prone to data attrition,[25] necessitating feasible data collection tools. This study therefore constructed a web-based questionnaire tailored for longitudinal investigation of work exposure, health and performance in HPMCP.

METHODS

Design

In three steps, a web-based questionnaire in English was developed, validated and pilot-tested in collaboration between the Royal Institute of Technology, Karolinska Institutet, the Swedish Coast Guard and the Norwegian Special Operations Command. Content domains were defined, items were generated, and the questionnaire was outlined by a consensus panel. The questionnaire draft was then assessed by experts in an iterative validation procedure, and the validated questionnaire pilot-tested in a study population sample.

Consensus panel and expert raters

The present authors constituted the consensus panel: two engineers with theoretical and empirical experience in naval architecture, specialists in high-speed marine craft; and two

physiotherapists with experience in epidemiologic investigations, biomechanical studies and questionnaire development.

In accordance with previous recommendations based on their knowledge of the content domains, research methodology and statistical analysis,[26] ten independent experts from Sweden, Norway and England enrolled for participation: four women and six men (Table 1).

[TABLE 1: ABOUT HERE]

Development procedure

The questionnaire content was concentrated on key aspects in the previously identified domains of work exposure, health and performance[18] to provide a more comprehensive coverage of these features. The literature was reviewed to isolate suitable parameters for domain quantification, and items were selected to reflect central features of the measured constructs while balancing content across domains. Items were evaluated based on their analytical value and the questionnaire was designed to be linked to accelerometer data for objective VRS quantification. Sampling periods were selected to capture accurately the measured variables and to reduce recall bias. To optimize the questionnaire for longitudinal measurements, the balance between data quality and respondent burden was carefully considered, with items selected and web-mechanisms implemented to minimize the total number of items. In addition, with the propensity of longitudinal designs for data attrition, optional items were added to facilitate missingness assumptions necessary for result inferences.[25] Finally, to evaluate the experts' concentration level, a control item inquiring about music preference at sea was included in the first questionnaire draft.

Validation procedure

In three consecutive stages, experts assessed individual items by rating their relevance and simplicity on two separate 4-point Likert-type scales: 'not relevant/not simple', 'somewhat relevant/somewhat simple', 'quite relevant/quite simple' and 'very relevant/very simple'. Ratings were dichotomized so that the two lowest and the two highest options represented non-relevant/non-simple and relevant/simple, respectively.[27 28] In addition, experts could comment on individual items and the questionnaire as a whole, and were invited to provide general feedback on the questionnaire's comprehensiveness and length. Taking into consideration the experts' feedback, items were revised, added or discarded by the consensus panel between each validation stage. Prior to the third stage, the questionnaire was professionally proofread and implemented online, and the experts were given access to the online version for evaluation in its intended environment.

An item-level content validity index (I-CVI) was computed for relevance and simplicity as the proportion of experts rating an item as relevant or simple, respectively,[27 28] with 0.78 selected as the threshold for an acceptable I-CVI.[28 29] A scale-level content validity index was calculated as the average across items' I-CVI (S-CVI/Ave) and as the proportion of items which all experts rated as relevant or simple (S-CVI/UA), with selected thresholds of 0.90 and 0.80 for an acceptable S-CVI/Ave and S-CVI/UA, respectively.[27 28] A more detailed description of the validation procedure is provided elsewhere.[18]

Pilot test

To assess the questionnaire's feasibility and to preliminarily evaluate item properties, it was pilot-tested in a convenience sample of eight Norwegian Special Operations Command officers during a marine exercise where high-speed planing craft were regularly operated. Everyone invited agreed to participate in the study. The participants were men aged 28–40

years, with 1–20 years of work experience at sea, who regularly manoeuvred and navigated marine craft.

The questionnaire was completed on the respondents' personal cell phones, and participants were instructed to complete one section on exposure and performance at the end of each work shift and one section on health once weekly over a one-month period. In addition, their craft were instrumented to collect the acceleration time-history data at sea to enable data comparison. Following the pilot test period, the subjects provided verbal feedback on the questionnaire.

RESULTS

An overview of the questionnaire construction process is given in Figure 1 and the final questionnaire in the supplementary materials.

Development

The work exposure domain focused on the crew's operational environment and contained items related to work: duration, environment and task. One item identified craft ID to permit linkage between questionnaire data and objective data, and a ride-quality item was included as a measure of ride roughness,[30] useful both as an indicator of VRS exposure when objective data is unavailable and for identifying acceleration features affecting the perception of ride roughness. Items regarding body posture and crew gear, environmental conditions, mission and work task were included for their biomechanical relevance,[5] reported influence on impaired health and performance[19-21] and relevance to mental and physical demands, respectively.

The health domain focused on work-related musculoskeletal pain, it being previously associated with VRS exposure and one of the main areas of concern among HPMCP.[2] Pain

occurrence was considered the main variable and auxiliary items were included to describe its characteristics. In line with established recommendations for chronic pain measurement selected auxiliary items inquired about pain location, pain intensity, pain frequency and physical functioning impairment.[31 32] Pain location was mapped with a previously developed 16-zone figure to maintain compatibility with the former questionnaire[18] and additional sub-items related to the specific locations. Pain intensity was assessed with a standard formulation used to reflect the average pain magnitude over the past week and measured on an 11-point numeric rating scale.[31] Pain frequency was quantified by providing a daily schedule split between day and night, allowing for a rapid selection of pain occurrence, and simultaneously permitting quantification of pain patterns and association of pain and exposure. Physical function impairments were considered in relation to reduction in work ability, since this parameter involves both practical and financial ramifications. Finally, one item inquiring about perceived cause of pain was included for its descriptive value.

Performance was mainly measured indirectly via fatigue symptoms, as they have been associated with impaired performance.[3 4 33 34] Fatigue is a subjective experience constituting of several dimensions.[34 35] Mental fatigue was targeted since it closely reflects performance impairments in common work tasks among HPMCP. A composite summary score derived from 4–5 items encompassing different aspects of fatigue was considered the most suitable method to capture the latent fatigue construct.[34 35] Selected fatigue items were inspired by previous questionnaires,[34 36] and adapted to the study population. In addition to the fatigue summary score items, two items for self-rated human and craft performance were included.

Sampling periods were selected considering the characteristics of the measured attributes. Items related to work exposure and fatigue targeted the previous work shift, as work exposure can vary greatly between days, acute fatigue presumably is reversed with rest and both are somewhat diffuse and mundane, which could impede accurate recollection.[23] In contrast,

musculoskeletal pain items targeted the previous week, as prolonged VRS exposure conceivably causes overload injuries which persist between days, and as a pain event likely is perceived as more distinct and salient, which facilitates accurate recollection.[23]

To reduce bias related to missing data, one optional item was added with response options defined to support different missing data assumptions.[25] Refusal to respond to an item was managed by incorporating a hidden response option (i.e., 'I do not want to answer this question'), which appeared only when respondents attempted to skip an item. Selection of this option strongly suggests that missingness is related to the item itself.

To maintain the respondent burden at an acceptable level, the option to deactivate redundant items (e.g., the duration-at-sea item when time at sea is registered elsewhere), a dynamic mechanism which automatically skips redundant items, and only closed-ended response options (i.e., predetermined responses selected from a list) were incorporated. With all items active, the dynamic mechanism reduced daily items related to work exposure and performance from 19 to seven when respondents had not worked at sea, and limited the maximum number of weekly items related to pain to 14 by leading to auxiliary pain items inquiring about the worst and the least painful areas when more than three pain locations were selected.

[FIGURE 1: ABOUT HERE]

Validation

The first questionnaire draft contained 28 items (excluding the control item which all experts rated as non-relevant), of which 13 were related to work exposure, six to pain, seven to performance and two to missing data. Ratings by 10 experts revealed acceptable I-CVI for

simplicity and relevance of 26 items, thereby exceeding the threshold of 0.90 for an acceptable S-CVI/Ave in the first stage. However, 90 item-specific expert comments at this stage prompted further item refinement. Based on this feedback, 18 items were revised, two were added to enhance the fatigue summary score, and one on mission status was discarded as inapplicable to subgroups of the study population.

The second questionnaire draft of 29 items was rated by nine experts, as one expert discontinued the process. Whereas 28 items met the cut-off for an acceptable I-CVI, 45 expert comments again indicated opportunities for further improvements. Accordingly, 12 items were modified and three were removed: one related to shock mitigation at sea since it was considered redundant, and two related to the fatigue summary score since they were found confusing or redundant.

The third and final 26-item questionnaire draft was also rated by nine experts, with 25 items having an acceptable I-CVI for both relevance and simplicity, amounting to an S-CVI/Ave of 0.97 and 1.00, and an S-CVI/UA of 0.85 and 0.96 for relevance and simplicity, respectively. Eight of nine experts commented on the overall questionnaire. All responded that the questionnaire was good to very good; four replied that no additional items were needed while three suggested adding items related to sleep quality, suspension system and in-land work; four suggested that it was of good length while four felt it was slightly too long. The 'headache' item (item 12) failed to meet acceptable I-CVI for relevance, was rejected by three of nine experts, but was nonetheless retained for further assessment because of its potential value as a fatigue indicator. Table 2 details the results of the validation process.

[TABLE 2: ABOUT HERE]

Pilot test

The pilot test suggested that the completion time for both questionnaire parts combined was approximately 10 minutes. Of eight subjects, seven participated in the daily part about work exposure and performance and five in the weekly part about musculoskeletal pain. Over the one-month period, these respondents completed each part 2–15 and 1–5 times, amounting to a total of 58 and 12 observations, respectively. During the same period, acceleration was registered on 11 occasions between three subjects.

Data obtained indicated that the questionnaire's psychometric properties were acceptable. Responses had either uniform or unimodal distributions across item categories. The 'Other' option available for some items was never selected, and no participants elected to avoid any item response. Exposure-related items registered similar ratings for subjects on the same craft, and there were no contradictory ratings. Of 14 occasions, 7–10 ratings each for ride quality, sea conditions, wind conditions, noise level and temperature, and 3–5 ratings each of sea spray and visibility were identical between subjects, and ratings differed by at most two categories.

The 'ride-quality' item showed sensitivity to acceleration exposure (Figure 2), and the fatigue summary score items showed sensitivity to ride quality (Figure 3). However, because the response distribution in the fatigue items suggested that a potential floor effect might be present, which could be detrimental to fatigue discrimination, some changes were made to increase sensitivity. The 'memory' item, excluded in the validation process based on expert comments – and which nevertheless met the criterion for an acceptable I-CVI – was re-integrated for further evaluation. Moreover, the 'concentration', 'decision' and 'memory' items were revised to accommodate a bipolar response structure (i.e., 'Very high' to 'Very low'), and an additional response category was added to both the 'headache' and 'tiredness' items. Final modifications were also implemented with respect to the musculoskeletal pain items. Feedback from the subjects revealed that they lacked a response option for absence of

pain while under pain relief medication; the response structure of the 'pain event' item was therefore revised to accommodate this. Finally, the 'perceived pain cause' item was removed to reduce the respondent burden.

[FIGURE 2: ABOUT HERE]

[FIGURE 3: ABOUT HERE]

DISCUSSION

This study developed, validated and pilot-tested a questionnaire for longitudinal investigation of work exposure, musculoskeletal pain and performance in high-performance marine craft personnel (HPMCP). Ratings from nine experts computed to an S-CVI/Ave of 0.97 and 1.00 for relevance and simplicity, respectively, supported excellent content validity, and the pilot test suggested that the questionnaire, following some adjustments, was feasible for its intended purpose.

The expert ratings supported that the questionnaire content was both relevant with respect to the intended content domains and simple to understand. In the first validation stage the S-CVI/Ave already exceeded the commonly used threshold of 0.90;[27 28] however, expert item-level disagreement and the multiplicity of comments indicated that further improvements were possible. Items were noticeably refined in subsequent stages, as reflected by the increase in S-CVI/UA, which improved from 0.64 and 0.50 in the first stage to 0.85 and 0.96 in the final stage for relevance and simplicity, respectively, thereby meeting the acceptability criterion of 0.80 for both.[27 28] Most expert comments supported that the questionnaire was sufficiently comprehensive. The additional items suggested by three experts were decided against, since they either were indirectly measured or were too peripheral to motivate the additional respondent burden.

Although our content validity indices were exceptionally high in comparison both to our previous questionnaire and to reported results of other questionnaires,[18 27] certain adjustments were necessary to finalize the questionnaire. Item 12 ('headache') failed to meet an acceptable I-CVI for relevance but was nonetheless retained, as expert comments suggested that this was due to a lack of understanding of its intended purpose as a fatigue summary score item. This decision was supported by the pilot-test results which indicated that it was sensitive to ride roughness. In addition, a potential floor effect detected by inspecting the distribution in fatigue-related items prompted the return of item 15 ('memory') and the changes in the response structure of all fatigue-related items.

The chosen item recall periods were in line with general principles of recollection accuracy.[23] Frequent everyday-events are typically estimated more imprecisely than rare and prominent events,[23] which supported a shorter recall period for work exposure and fatigue-related items than for pain-related items. Studies on fatigue recollection suggest that the daily recall bias is within an acceptable level,[22 37] whereas studies on pain recollection indirectly suggest that the 7-day recall bias of the pain event itself is within an acceptable level; however, that the pain intensity is systematically slightly overestimated.[22 24]

While the results from both the validation process and the pilot test supported the adequacy of the questionnaire in quantifying the content domains, it could involve a considerable respondent burden as the final version contains up to 30 items. Upon initial review, the response rate suggested that there was a problem with the feasibility of the questionnaire for longitudinal measurements. The secrecy of the group investigated prevented determination of the exact response rate and attached causes (e.g., respondents' work schedules were classified); however, respondent feedback revealed that they were not allowed to use their cell phones during a one-week exercise and that two intended subjects did not participate in the marine exercise and therefore dropped out. In addition, Norwegian occupational regulations

demand an average two-day rest per week. Accounting for these factors, we approximated a response rate of >85% for three subjects and 10–40% for the three remaining subjects in the daily questionnaire section, and 100% for one subject, 50% for three subjects and 0–25% for two subjects in the weekly questionnaire section. Thus, in this pilot study, half the respondents had an acceptable response rate for the daily section, but only one of six for the weekly section. Respondent feedback suggested that the low response rate for the weekly section was related to the division of the questionnaire into two parts, and both sections were therefore incorporated into a single web-questionnaire. Noteworthy is that in this pilot test, we maximized the respondent burden both in sampling frequency, once following each work shift, and in total questionnaire items. Decrease of either of these two aspects would likely increase questionnaire feasibility for longitudinal investigation.

This study has some limitations. Whereas a large number of experts were included in the questionnaire validation to provide a suitable breadth of knowledge across content domains and to lessen the risk of chance agreement,[28] its validity is limited by the proficiency of the expert raters and the consensus panel. Likewise, the results of this pilot test, conducted in a sample chosen to represent HPMCP subjected to the most intense VRS exposure, are limited by the small sample size. With respect to the questionnaire content, performance was indirectly measured via fatigue, as performance and fatigue have previously been associated[3 4 33 34] and as performance is hard to capture with self-reported data. To know how far the questionnaire items actually measure performance it is, however, necessary to link them to objective performance indicators.

The present questionnaire was developed as a complement to the previously constructed questionnaire.[18] In conjunction with objective exposure data, the two questionnaires provide a means to quantify the extent of musculoskeletal pain and performance impairments in

HPMCP, and to link the contribution of VRS exposure causally to these effects. However, for accurate inferences, their psychometric properties should be further evaluated.

CONCLUSIONS

A dynamic web-based questionnaire for longitudinal investigation of work exposure, musculoskeletal pain and performance impairments in high-performance marine craft populations was constructed. Expert ratings supported that the questionnaire content was relevant, simple and sufficiently comprehensive. A pilot test suggested that the questionnaire, following some adjustments, was feasible for longitudinal measurements in the study population.

ACKNOWLEDGEMENTS

We thank the expert raters for their feedback, and the Norwegian Special Operations Command officers for their participation in the pilot test. We also thank Lea Constan for excellent feedback on the manuscript, Jan Ivar Kåsin from the Norwegian Institute of Aviation Medicine for connecting us to experts and pilot test subjects from the study population, and Stefan Andersson from the Swedish Coast Guard for providing experts from the study population.

CONTRIBUTIONS

KG is leading the research program of which this study is a part. All authors conceived and designed the study, and constituted the consensus panel. RLM and MPdA outlined the questionnaire and refined it in accordance with the experts' feedback. RLM implemented the questionnaire online and drafted the manuscript, and MPdA, KG and BOA reviewed and contributed to the manuscript's development. All authors read and approved the final manuscript.

FUNDING

The Gösta Lundeqvist Foundation for Ship Research (Gösta Lundeqvists stiftelse för skeppsteknisk forskning) and the Swedish Maritime Administration (Sjöfartsverket).

COMPETING INTERESTS

None declared.

ETHICS APPROVAL

Ethics approval was obtained from the Regional Committee for Medical Research Ethics (Dnr. 2015/576-31), Stockholm, Sweden. All participants received study information and signed an informed consent.

DATA-SHARING STATEMENT

No additional data available.

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FIGURE CAPTIONS

Figure 1. Flow chart of the questionnaire construction process.

Figure 2. Sampled acceleration relative to self-reported ride quality for the only three subjects with complete data. VDV, vibration dose value computed as in ISO 2631-1.[38]

Figure 3. The four top graphs show fatigue-related ratings per ride quality category and the bottom graph shows the number of fatigue symptoms defined as ratings other than 'No' for each observation. Figures are based on 58 observations from repeated measurements in seven subjects.

TABLES

Table 1. Expert characteristics.

Expert	Profession	Area of expertise
1	Special operations command officer	HSC operations, target population.
2	Special operations command officer	HSC operations, target population.
3	Coastguard officer	HSC operations, target population.
4	Coastguard officer	HSC operations, target population.
5	Engineer, researcher	HSC human factors engineering.
6	Engineer, researcher	HSC human factors engineering.
7	Physician, researcher	Medicine, human biomechanics, content validity.
8	Physiotherapist, researcher	Epidemiology, questionnaire development, musculoskeletal pain.
9	Physiotherapist, researcher	Questionnaire development, musculoskeletal pain.
10	Physiotherapist	Occupation therapist in the study population.

HSC, high-speed craft

Table 2. Expert ratings across the three validation stages.

		Relevance						Simplicity					
		Stage 1 (*n*=10)		Stage 2 (*n*=9)		Stage 3 (*n*=9)		Stage 1 (*n*=10)		Stage 2 (*n*=9)		Stage 3 (*n*=9)	
Domain	**Item**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**	**Rating**	**I–CVI**
Work exposure	Hours at sea	4–4	1.00	3–4	1.00	4–4	1.00	1–4	0.90	3–4	1.00	4–4	1.00
	Ride quality	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Craft ID	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	4–4	1.00	4–4	1.00
	Craft experience	3–4	1.00	3–4	1.00	3–4	1.00	2–4	0.90	4–4	1.00	3–4	1.00
	Mission	2–4	0.90	4–4	1.00	4–4	1.00	2–4	0.90	3–4	1.00	4–4	1.00
	Task	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	4–4	1.00	4–4	1.00
	Open deck	1–4	0.70	4–4	1.00	4–4	1.00	2–4	0.60	3–4	1.00	4–4	1.00
	Equipment	2–4	0.90	4–4	1.00	3–4	1.00	2–4	0.90	3–4	1.00	4–4	1.00
	Body posture	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	2–4	0.89	3–4	1.00
	After dark	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00
	Environmental conditions	1–4	1.00	3–4	1.00	4–4	1.00	3–4	0.90	2–4	0.89	3–4	1.00
	Shock mitigation*	3–4	1.00	2–4	0.89	–	–	2–4	0.90	4–4	1.00	–	–
	Craft ergonomics	3–4	1.00	2–4	0.89	4–4	1.00	1–4	0.80	1–4	0.89	4–4	1.00
	(Music preference)	1–2	0.00	–	–	–	–	1–4	0.60	–	–	–	–
Pain	Pain event	2–4	0.90	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Pain location	3–4	1.00	4–4	1.00	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00
	Pain frequency	3–4	1.00	4–4	1.00	3–4	1.00	2–4	0.90	2–4	0.78	3–4	1.00
	Pain intensity	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00

	Pain consequences	4–4	1.00	4–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Perceived pain cause	3–4	1.00	3–4	1.00	4–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
Performance	Headache	2–4	0.90	2–4	0.78	2–4	0.67	3–4	1.00	4–4	1.00	3–4	1.00
	Concentration	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Decisions[+]	–	–	3–4	1.00	2–4	0.89			3–4	1.00	3–4	1.00
	Memory[+,*]	–	–	2–4	0.78	–	–	–	–	3–4	1.00	–	–
	Effort of thinking*	1–4	0.80	1–4	0.67	–	–	2–4	0.70	3–4	1.00	–	–
	Tiredness	2–4	0.70	2–4	0.89	3–4	1.00	2–4	0.80	4–4	1.00	4–4	1.00
	Human performance	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00	3–4	1.00
	Craft performance	2–4	0.90	3–4	1.00	2–4	0.78	2–4	0.80	3–4	1.00	2–4	0.89
	Mission status*	2–4	0.80	–	–	–	–	2–4	0.90	–	–	–	–
Missing data	Reason for non-response	2–4	0.90	4–4	1.00	2–4	0.89	3–4	1.00	4–4	1.00	4–4	1.00
	Perceived pain cause	3–4	1.00	3–4	1.00	3–4	1.00	2–4	0.80	3–4	1.00	4–4	1.00
S–CVI/Ave			0.91		0.96		0.97		0.91		0.98		1.00
S–CVI/UA			0.64		0.79		0.85		0.50		0.86		0.96

I-CVI, item-level content validity index: proportion of expert ratings higher than two. S-CVI/Ave, scale-level content validity index average: mean I-CVI across items. S-CVI/UA, scale-level content validity index universal agreement: proportion of items which all experts rated higher than two. Thresholds for acceptable I-CVI, S-CVI/Ave, and S-CVI/UA were 0.78, 0.90, and 0.80, respectively. *, discarded item. [+], added item. (), control item.

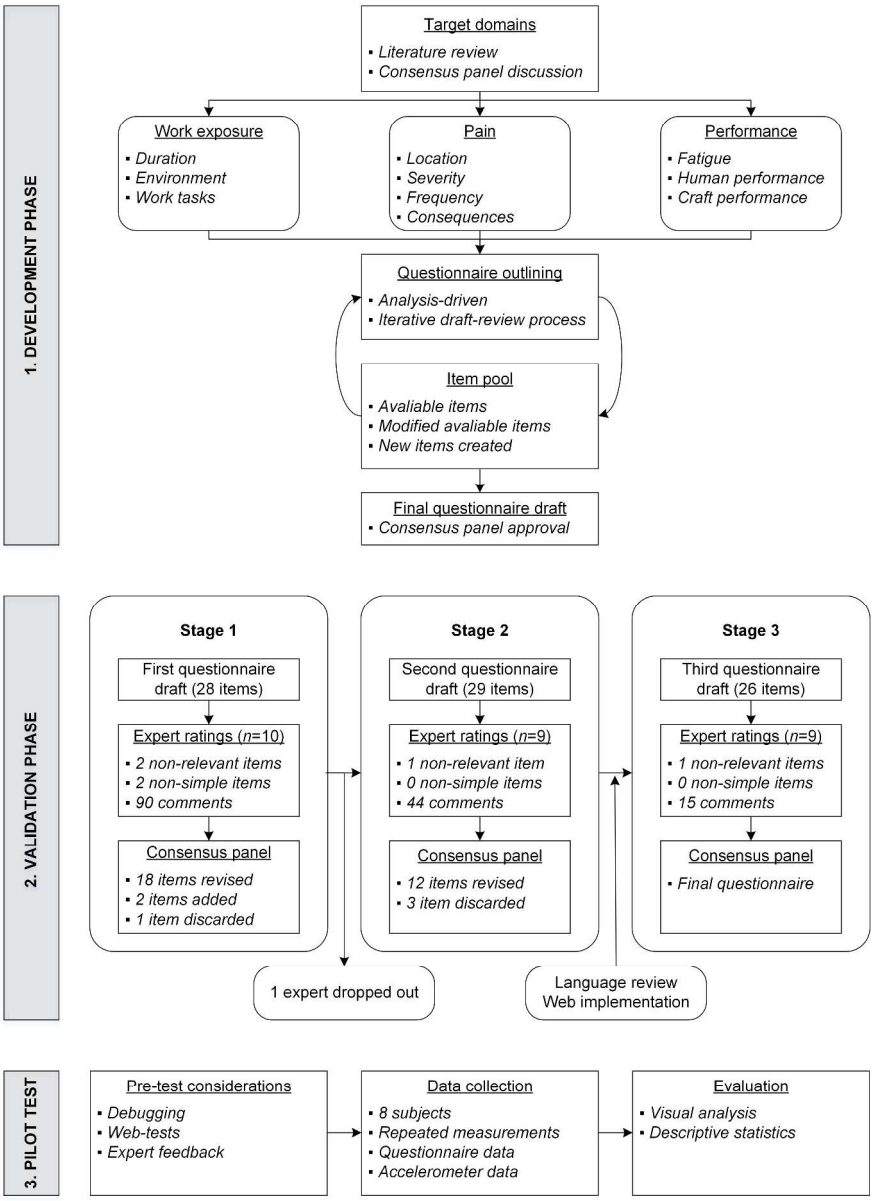
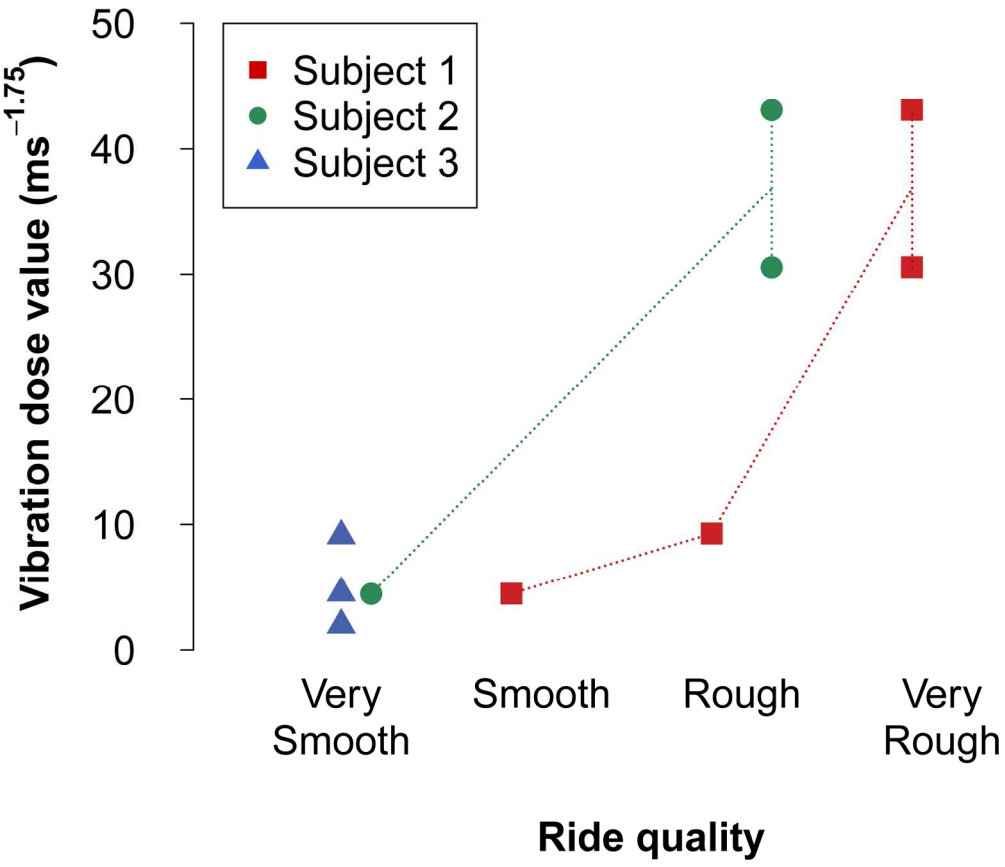


Figure 1. Flow chart of the questionnaire construction process.

380x524mm (300 x 300 DPI)



Sampled acceleration relative to self-reported ride quality for the only two three subjects with complete data. VDV, vibration dose value computed as in ISO 2631-1.[38]

173x149mm (300 x 300 DPI)

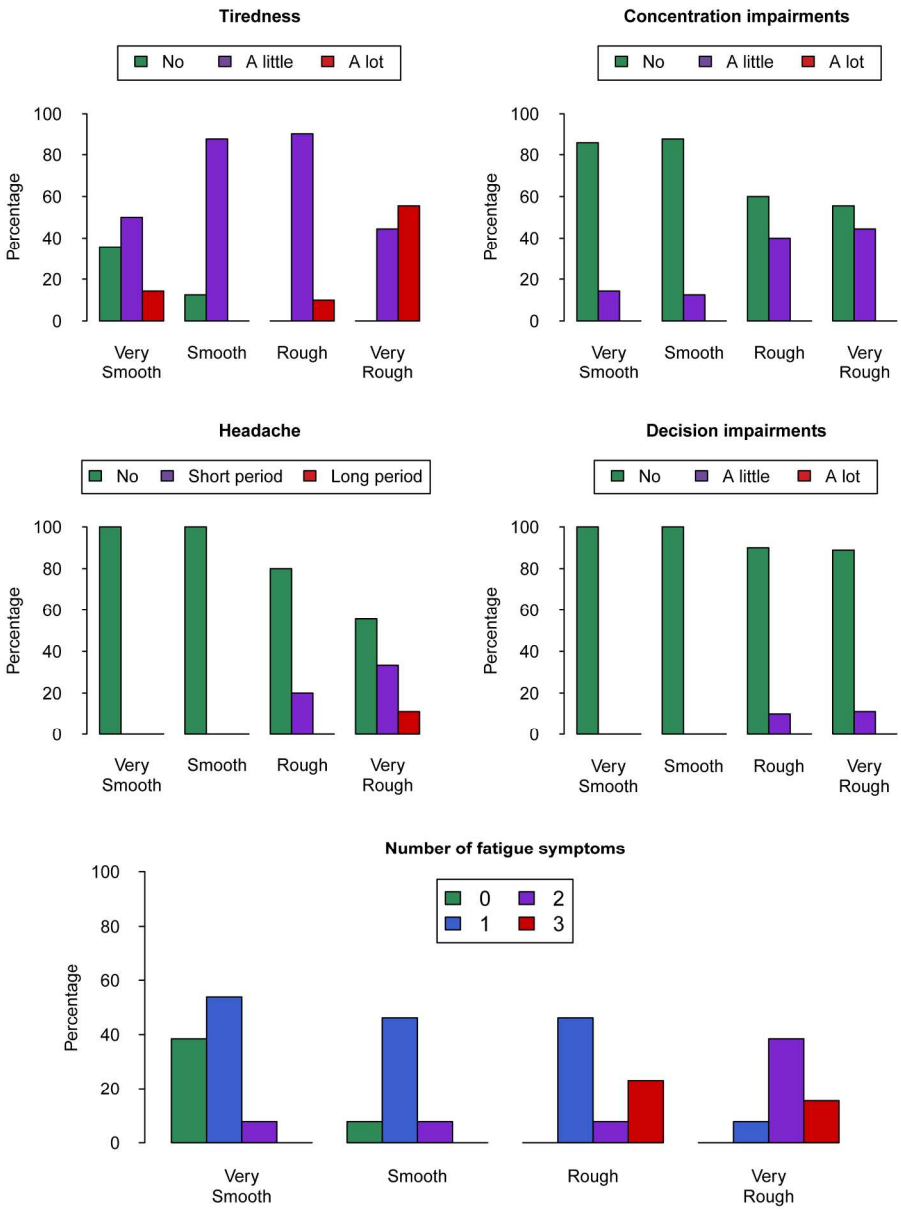


Figure 3. The four top graphs show fatigue-related ratings per ride quality category and the bottom graph shows the number of fatigue symptoms defined as ratings other than 'No' for each observation. Figures are based on 58 observations from repeated measurements in seven subjects.

181x243mm (300 x 300 DPI)

Questionnaire on Work Exposure, Musculoskeletal Pain, and Performance among High-Performance Marine Craft Personnel

This survey investigates work exposure, musculoskeletal pain, and performance among high-performance marine craft personnel, and your participation is important as you have relevant skills. In total, it contains about 25 questions which take roughly 10 minutes to complete.

Your responses are *strictly confidential*, will be processed *anonymously*, and are used only for this investigation.

Please read the questions carefully and answer honestly.

Thank you for your time**.**

EXPOSURE AND PERFORMANCE MODULE (ADMINISTERED DAILY)

The following questions concern your last work shift (i.e., the one you just completed or are about to complete just now).

1. **How many hours of this work shift did you spend at sea (i.e., away from the pier)?**
   Please include time inactive (e.g., breaks, sleep at work, or standby).

   [DROPDOWN LIST] hours

---

2. **How would you rate ride quality aboard the craft during this work shift?***
   Ride quality refers to the comfort of the boat ride.

   ☐ Very smooth *(good comfort with no or very few bumps)*
   ☐ Smooth
   ☐ Rough
   ☐ Very rough (considerable *discomfort or strain as a result of sea state, vessel speed, or both)*

---

* Condition: >0 hours selected in item 1.

3. **Please select the craft you worked onboard during this shift:***
   If you worked onboard more than one craft, select them in the order you were on them, starting with '1' for the first craft.

   ☐ Craft ID 1**
   ☐ …
   ☐ Other

---

* Condition: >0 hours selected in item 1. ** Craft ID 1 used as an example.

4. **How familiar are you with *Craft ID 1***?***

   ☐ I have *a lot* (months) of experience working aboard that particular craft
   ☐ I have *some* (weeks) experience working aboard that particular craft
   ☐ I have *no or almost no* (days) experience working aboard that particular craft

---

* Condition: Craft ID selected in item 3. ** Craft ID 1 used as an example.

5. **Please select the options that best describe your work at sea during this shift:***
   Multiple options possible.

   ☐ Patrol
   ☐ Search and Rescue
   ☐ Transport *(person or cargo)*
   ☐ Firefighting
   ☐ Law enforcement or other offensive mission
   ☐ Other

---

* Condition: >0 hours selected in item 1.

6. What was your *main* task at sea during this work shift?*

☐ Craft driving
☐ Craft navigation
☐ Work on deck
☐ Work on engine or other machinery
☐ Active duty onboard *(e.g., lookout or equipment operator)*
☐ Passenger
☐ Other

* Condition: >0 hours selected in item 1.

7. Did you perform your *main* task on open deck during this work shift?*

☐ No
☐ Yes

* Condition: >0 hours selected in item 1.

8. What equipment were you wearing at sea during this work shift?*
Multiple options possible.

☐ Helmet
☐ Vest *(e.g., body armour)*
☐ Weapon or equipment belt
☐ Survival suit *(i.e., immersion suit or dry suit)*
☐ Night vision goggles
☐ Other
☐ None

* Condition: >0 hours selected in item 1.

9. Which body posture best describes your work at sea during this shift?*

☐ Sitting regardless of sea condition
☐ Standing regardless of sea condition
☐ About half the time sitting and half the time standing
☐ Mainly sitting, but standing in rough sea conditions
☐ Mainly standing, but sitting in rough sea conditions

* Condition: >0 hours selected in item 1.

10. How much time did you spend at sea after dark during this work shift?*

☐ 0%
☐ 25%
☐ 50%
☐ 75%
☐ 100%

* Condition: >0 hours selected in item 1.

11. Please select the option that best describes this work shift's…*

…sea conditions?	☐ Calm *(Like a mirror.)* ☐ Smooth *(Ripples or wavelets without or with few with caps.)* ☐ Moderate *(Small waves with breaking crests. Fairly frequent white caps.)* ☐ Rough *(Long waves and very frequent white foam crests. Some sea spray.)* ☐ High *(High waves whose crests sometimes roll over. Dense white foam. Large amounts of sea spray.)*
…wind conditions?**	☐ Calm ☐ Light breeze ☐ Moderate breeze ☐ Strong breeze ☐ Gale
…sea spray?**	☐ Very little ☐ Some ☐ Moderate ☐ Much ☐ Very much
…visibility? *Refer to the visibility that affected your work the most (e.g., inside boat: low light, instrument back light etc; outside boat: fog, sunshine reflection etc).*	☐ Excellent ☐ Very good ☐ Good ☐ Acceptable ☐ Poor
…noise level?	☐ Quiet ☐ Faint ☐ Moderate ☐ Uncomfortable ☐ Intolerable
…temperature? *Refer to the temperature that affected you the most.*	☐ Uncomfortably hot ☐ Hot ☐ Comfortable ☐ Cold ☐ Uncomfortably cold

* Condition: >0 hours selected in item 1. ** Condition: 'Yes' selected in item 7.

12. Did you suffer from headache during this work shift?

☐ No, not at all
☐ Yes, for a short period
☐ Yes, for a long period
☐ Yes, for nearly the entire work shift

---

13. How would you rate your ability to concentrate during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

14. How would you rate your ability to make decisions during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

15. How would you rate your ability to remember things during this work shift?

☐ Very high
☐ High
☐ Low
☐ Very low

---

16. Do you feel tired right now?
'Right now' refers to the end of the past work shift

☐ No, I feel completely rested
☐ Yes, a little tired
☐ Yes, very tired
☐ Yes, exhausted

---

17. How would you rate your working performance during this shift?

☐ Very good
☐ Good
☐ Moderate
☐ Poor
☐ Very poor

---

18. How would you rate the craft's performance with respect to this shift's activities?*

☐ Very good *(craft performed well in the conditions)*
☐ Good
☐ Moderate
☐ Poor
☐ Very poor *(craft was unable to cope with the conditions)*

* Condition: >0 hours selected in item 1.

19. How suitable were the craft ergonomics (e.g., controls, equipment, and/or interior of the sea vessel) for this work shift's missions?*

☐ Perfectly suitable
☐ Good, but there is room for improvement
☐ Not so good, they reduced my work performance
☐ Poorly suitable

* Condition: >0 hours in selected item 1.

PAIN MODULE (ADMINISTERED WEEKLY)

The following questions concern the past 7 days.

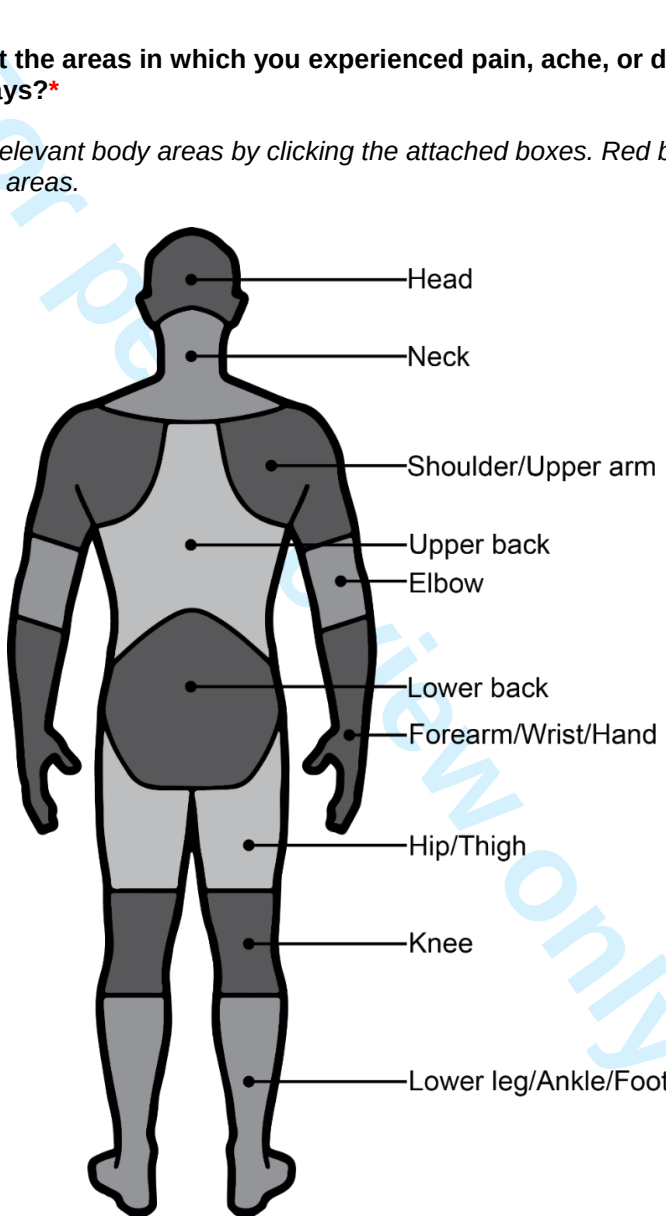
20. Have you experienced pain, ache, or discomfort during the past 7 days?

☐ No, and I was *not* taking pain relief medication
☐ No, but I was taking pain relief medication
☐ Yes

---

21. Please select the areas in which you experienced pain, ache, or discomfort during the past 7 days?*

Please mark relevant body areas by clicking the attached boxes. Red boxes indicate selected body areas.



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* Condition: 'Yes' selected in item 20.

Please select all periods during which you experienced *neck* pain, ache, or discomfort during the past 7 days:***

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day-time							
Night-time							

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

Please rate the intensity that best describes your average *neck* pain, ache, or discomfort during the past 7 days:***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No pain										Worst possible pain

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

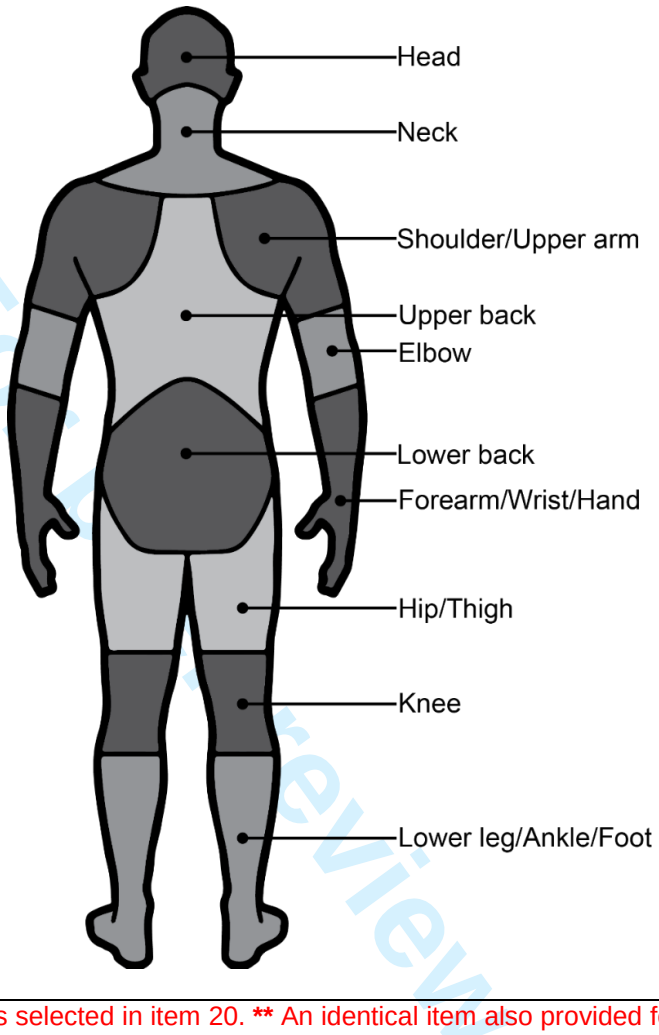
Did the *neck* pain, ache, or discomfort during the past 7 days reduce your work ability?**

☐ No, not at all
☐ Yes, somewhat
☐ Yes, a lot (e.g., it required me to temporarily change work task)
☐ Yes, it required sick leave

* Condition: Body area selected in item 20 AND ≤3 body areas selected in total. ** Neck used as an example.

Please select the area in which you experienced *the worst* pain, ache, or discomfort during the past 7 days?***

Please mark the body area by clicking the attached box. A red box indicate a selected body area.



* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Please select all periods during which you experienced pain, ache, or discomfort *in the area with the worst pain* during the past 7 days:***

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day-time							
Night-time							

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Please rate the intensity that best describes your average pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 days:***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No pain										Worst possible pain

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

Did the pain, ache, or discomfort *in the area with the worst* *pain* during the past 7 days reduce your work ability?***

☐ No, not at all
☐ Yes, somewhat
☐ Yes, a lot (e.g., it required me to temporarily change work task)
☐ Yes, it required sick leave

* Condition: ≥4 body areas selected in item 20. ** An identical item also provided for the least painful area.

MISSING DATA MODULE (ADMINISTERED FOLLOWING RETURN AFTER FAILURE TO RESPOND)

1. **Please select the reason for not completing the questionnaire *last week**:**

☐ I did not have the possibility to do it
☐ I forgot
☐ I was not at work
☐ I was too tired
☐ I was on sick leave related to pain, ache, or discomfort
☐ Other

---

* Last week used as an example

Questionnaire on Work Exposure, Musculoskeletal Pain and Performance Impairments among High-Performance Marine Craft Personnel

This survey investigates work exposure,musculoskeletal pain and performance impairments among high-performance marine craft personnel, and your participation is important as you have relevant skills. In total, it contains about 25 questions which take roughly 10 minutes to complete.

Your responses are *strictly confidential*, will be processed *anonymously*, and are used only for this investigation.

Please read the questions carefully and answer honestly.

Thank you for your time.

By clicking on the check box below stating *"Yes, I agree to participate in the study"* and the *"Next"* button, you confirm that you have taken part of, and understood, the study's purpose and procedure; and that you have had opportunity to ask questions related to your participation in the study. Your involvement is voluntary, and you may at any time terminate your participation, without stating the cause.

- [x] Yes, I agree to participate in the study

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Do you want to respond to the pain questions now?
Please respond to these questions at least one time per week.

- (x) Yes
- ( ) No

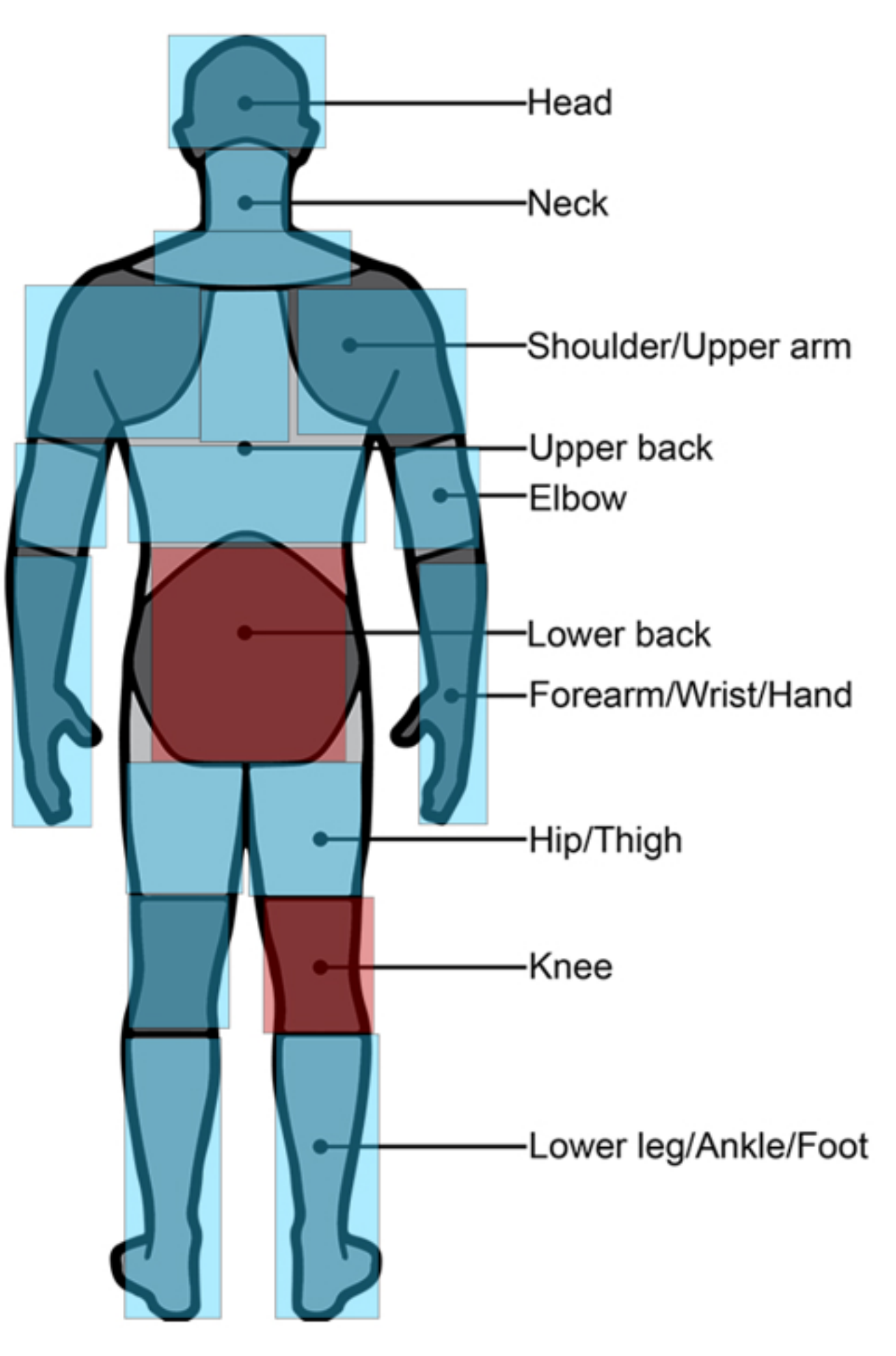
The following questions concern the past 7 days.

1. Have you experienced pain, ache, or discomfort during the past 7 days?

- ( ) No, and I was *not* taking pain relief medication
- ( ) No, but I was taking pain relief medication
- (x) Yes

2. Please select the areas in which you experienced pain, ache, or discomfort during the past 7 days?

Please mark relevant body areas by clicking the attached boxes. Red boxes indicate selected body areas.



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You have indicated *lower back* pain

Please select all periods during which you experienced *lower back* pain, ache, or discomfort during the past 7 days:

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Daytime							
Nighttime							

Please rate the intensity that best describes your average *lower back* pain, ache or discomfort during the past 7 days:

- ( ) 0 *(none)*
- ( ) 1
- ( ) 2
- ( ) 3
- (x) 4
- ( ) 5
- ( ) 6
- ( ) 7
- ( ) 8
- ( ) 9
- ( ) 10 *(worst possible)*

Did the *lower back* pain, ache, or discomfort during the past 7 days reduce your work ability?

- ( ) No, not at all
- (x) Yes, somewhat
- ( ) Yes, a lot (e.g., it required me to temporarily change work task)
- ( ) Yes, it required sick leave

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You have indicated *right knee* pain

Please select all periods during which you experienced *right knee* pain, ache, or discomfort during the past 7 days:

Please mark relevant time periods by clicking the attached boxes. Red boxes indicate selected time periods.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Daytime							
Nighttime							

Please rate the intensity that best describes your average *right knee* pain, ache or discomfort during the past 7 days:

- ( ) 0 *(none)*
- ( ) 1
- ( ) 2
- (x) 3
- ( ) 4
- ( ) 5
- ( ) 6
- ( ) 7
- ( ) 8
- ( ) 9
- ( ) 10 *(worst possible)*

Did the *right knee* pain, ache, or discomfort during the past 7 days reduce your work ability?

- (x) No, not at all
- ( ) Yes, somewhat
- ( ) Yes, a lot (e.g., it required me to temporarily change work task)
- ( ) Yes, it required sick leave

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The following questions concern your last work shift (i.e., the one you just completed or are about to complete just now)

1. How many hours of this work shift did you spend at sea (i.e., away from the pier)?

Please include time inactive (e.g., breaks, sleep at work, or standby)

10 - 11 hours

2. How would you rate ride quality aboard the craft during this work shift?

Ride quality refers to the comfort of the boat ride.

- ( ) Very smooth *(good comfort with no or very few bumps)*
- (x) Smooth
- ( ) Rough
- ( ) Very rough *(considerable discomfort or strain as a result of sea state, vessel speed, or both)*

3. Please select the craft you worked onboard during this shift:

Multiple options possible

- [ ] M1
- [x] M2
- [ ] M3
- [ ] M4
- [ ] M5
- [ ] M6
- [ ] Other

For more than one craft, please indicate the order you were on the craft

example (if you were on M6 first and M3 second): M6, M3

4B. How familiar are you with *M2*?

- (x) I have *a lot of (months)* experience working aboard that particular craft
- ( ) I have *some (weeks)* experience working aboard that particular craft
- ( ) I have *no or almost no (days)* experience working aboard that particular craft

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5. Please select the option that best describe your work at sea during this shift:

Multiple options possible

- [x] Patrol
- [ ] Search and Rescue
- [x] Transport *(person or cargo)*
- [ ] Firefighting
- [ ] Law enforcement or other offensive mission
- [ ] Other

6. What was your *main* task at sea during this work shift?

- ( ) Craft driving
- ( ) Craft navigation
- (x) Work on deck
- ( ) Work on engine or other machinery
- ( ) Active duty onboard *(e.g., lookout or equipment operator)*
- ( ) Passenger
- ( ) Other

7. Did you perform your *main* task on open deck during this work shift?

- ( ) No
- (x) Yes

8. What equipment were you wearing at sea during this work shift?

Multiple options possible

- [x] Helmet
- [x] Vest (e.g., body armour)
- [x] Weapon or equipment belt
- [ ] Survival suit (i.e., immersion suit or dry suit)
- [ ] Night vision goggles
- [ ] Other
- [ ] None

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9. Which body posture best describes your work at sea during this shift?

- ( ) Sitting regardless of sea condition
- ( ) Standing regardless of sea condition
- (x) About half the time sitting and half the time standing
- ( ) Mainly sitting, but standing in rough sea conditions
- ( ) Mainly standing, but sitting in rough sea conditions

10. How much time did you spend at sea after dark during this work shift?

- ( ) 0%
- (x) 25%
- ( ) 50%
- ( ) 75%
- ( ) 100%

11A. Please select the option that best describes this work shift's *sea conditions*:

- ( ) Calm *(Like a mirror.)*
- ( ) Smooth *(Ripples or wavelets without or with few with caps.)*
- (x) Moderate *(Small waves with breaking crests. Fairly frequent white caps.)*
- ( ) Rough *(Long waves and very frequent white foam crests. Some sea spray.)*
- ( ) High *(High waves whose crests sometimes roll over. Dense white foam. Large amounts of sea spray.)*

11B. Please select the option that best describes this work shift's *wind conditions*:

- ( ) Calm
- ( ) Light breeze
- ( ) Moderate breeze
- (x) Strong breeze
- ( ) Gale

11C. Please select the option that best describes this work shift's *sea spray*:

- ( ) Very little
- ( ) Some
- ( ) Moderate
- (x) Much
- ( ) Very much

11D. Please select the option that best describes this work shift's *visibility*:

Refer to the visibility that affected your work the most (e.g., inside boat: low light, instrument back light etc; outside boat: fog, sunshine reflection etc).

- ( ) Excellent
- (x) Very good
- ( ) Good
- ( ) Acceptable
- ( ) Poor

11E. Please select the option that best describes this work shift's *noise level*:

- ( ) Quiet
- ( ) Faint
- ( ) Moderate
- (x) Uncomfortable
- ( ) Intolerable

11F. Please select the option that best describes this work shift's *temperature*:

Refer to the temperature that affected you the most.

- ( ) Uncomfortably hot
- ( ) Hot
- ( ) Comfortable
- (x) Cold
- ( ) Uncomforably cold

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12. Did you suffer from headache during this work shift?

- (x) No, not at all
- ( ) Yes, for a short period
- ( ) Yes, for a long period
- ( ) Yes, for nearly the entire work shift

13. How would you rate your ability to concentrate during this work shift?

- ( ) Very high
- (x) High
- ( ) Low
- ( ) Very Low

14. How would you rate your ability to make decisions during this work shift?

- (x) Very high
- ( ) High
- ( ) Low
- ( ) Very Low

15. How would you rate your ability to remember things during this work shift?

- ( ) Very high
- (x) High
- ( ) Low
- ( ) Very Low

16. Do you feel tired right now (now refers to the end of the work shift)?

- ( ) No, I feel completely rested
- (x) Yes, a little tired
- ( ) Yes, very tired
- ( ) Yes, exhausted

17. How would you rate your working performance during this shift?

- ( ) Very good
- (x) Good
- ( ) Moderate
- ( ) Poor
- ( ) Very poor

18. How would you rate the craft's performance with respect to this shift's activities?

- (x) Very good *(craft performed well in the conditions)*
- ( ) Good
- ( ) Moderate
- ( ) Poor
- ( ) Very poor *(craft was unable to cope with the conditions)*

19. How suitable were the craft ergonomics (e.g., controls, equipment, and/or interior of the sea vessel) for this work shift's missions??

- ( ) Perfectly suitable
- (x) Good, but there is room for improvement
- ( ) Not so good, they reduced my work performance
- ( ) Poorly suitable

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