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Body, Mind, and Vessel: Physical Fitness, Mental Well-Being, and Cognitive Load Management in Maritime Career Readiness

Boedojo Wiwoho Soetatmoko Jogo[1*], Saidal Siburian[2]
Maritime Institute, Sekolah Tinggi Ilmu Pelayaran Jakarta, North Jakarta, Indonesia[1,2]
[*]Corresponding author, e-mail: boedojo.jogo@stipmail.ac.id

Abstract— Maritime vocational education commonly evaluates cadet competence through academic examinations, seamanship assessments, and English communication proficiency, while physical fitness, mental well-being, and cognitive load management receive comparatively limited attention as integrated dimensions of career readiness. This study examined the relationships among physical fitness, mental well-being, cognitive load, and career readiness among Nautika cadets and evaluated an eight-week integrated wellness programme. A two-phase sequential design was employed. In Phase 1, data were collected from 180 Nautika cadets at three Jakarta-area maritime institutions using the 20-metre shuttle run test for estimated VO_2max, the Patient Health Questionnaire-9 (PHQ-9), the Paas Cognitive Load Questionnaire, and the Maritime Career Readiness Inventory (MCRI). In Phase 2, 90 cadets were randomly assigned to intervention ($n=45$) and waitlist control ($n=45$) groups. Baseline findings indicated that 61.1% of cadets had VO_2max values below 38 ml/kg/min, 28.3% reported at least mild depressive symptoms, and 47.2% reported high cognitive load during bridge simulation. Career readiness was significantly associated with VO_2max ($r=0.61$, $p<0.001$), PHQ-9 scores ($r=-0.58$, $p<0.001$), and cognitive load ($r=-0.54$, $p<0.001$). Following the intervention, the intervention group demonstrated significantly higher career readiness than the control group ($F(1,87)=24.83$, $p<0.001$, $\eta^2=0.222$). The findings indicate that maritime career readiness should be addressed as an integrated academic, physical, psychological, and cognitive construct. Maritime vocational institutions should incorporate structured physical training, progressive simulation design, and psychological skills development into Nautika education.

Keywords: *physical fitness; mental well-being; cognitive load; career readiness; maritime vocational education*

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1. Introduction

Maritime vocational education is designed to prepare cadets for professional responsibilities that require technical competence, operational skills, regulatory knowledge, communication ability, and the capacity to perform safely under demanding conditions. The International Maritime Organization's Standards of Training, Certification and Watchkeeping for Seafarers (STCW), as amended, establishes competency requirements for deck officers and emphasizes the importance of training and certification for safe maritime operations [1]. However, conventional maritime education tends to emphasize academic knowledge and technical competence more strongly than the physical, psychological, and cognitive conditions that influence how effectively these competencies can be applied in operational environments.

Maritime safety management also demonstrates that human competence is an important component of safe transportation systems. Previous research has emphasized the need for systematic identification of

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safety-related competencies and indicators within maritime operations [2]. This perspective suggests that professional readiness should not be limited to whether cadets can pass academic or technical examinations but should also consider their ability to maintain effective performance under operational demands.

The physical dimension is particularly relevant to deck officers. The STCW framework establishes medical fitness requirements for seafarers, including appropriate standards for vision, hearing, and general fitness for duty [1]. Nevertheless, general medical fitness does not necessarily provide a detailed assessment of cardiovascular endurance, muscular endurance, or the ability to sustain physical performance during prolonged watchkeeping. Deck officers may spend extended periods standing or moving on vessels exposed to motion and environmental stress while simultaneously monitoring navigation systems, interpreting radar and electronic chart information, communicating with crew and other vessels, and remaining prepared for emergency procedures. Occupational physiology literature has established the importance of cardiovascular capacity for maintaining performance during prolonged physical activity and environmental stress [3].

The importance of physical fitness has also been identified among maritime cadets. Pal et al. [4] reported that cardiovascular fitness should be considered from an occupational health perspective in maritime cadet preparation. Physical preparedness is particularly relevant because maritime personnel may be required to perform physically demanding emergency activities, including firefighting, man-overboard response, evacuation, and lifeboat operations. Consequently, physical fitness may represent an important but insufficiently measured component of maritime career preparation.

The psychological dimension represents another important component of cadet development. Maritime cadet education combines the demands of higher education with a highly structured institutional environment characterized by discipline, hierarchy, performance expectations, and preparation for prolonged separation from family and social networks. Psychological difficulties may affect concentration, motivation, confidence, academic performance, and the ability to assume professional responsibility. The Patient Health Questionnaire-9 (PHQ-9) is a widely validated instrument for assessing depressive symptoms and provides a practical screening measure for identifying students who may require additional psychological support [5].

The transition from cadet training to professional maritime employment may further increase psychological demands. Maritime education and training must prepare cadets not only to demonstrate technical competencies but also to adapt to changing operational environments and emerging forms of maritime technology [6]. This requirement makes psychological readiness and professional resilience increasingly relevant to the development of competent seafarers.

The cognitive demands of maritime operations provide a third dimension. Nautika cadets must progressively learn to integrate multiple information sources, including nautical charts, radar, Automatic Identification System (AIS) information, Electronic Chart Display and Information System (ECDIS), weather information, and radio communication. Cognitive Load Theory proposes that working memory has limited capacity and that excessive cognitive load can interfere with learning and performance in complex tasks [7]. Paas, Renkl, and Sweller further emphasize that instructional design should manage cognitive load so that learners can develop and automate task-related schemas [8]. These principles are particularly relevant to bridge simulation, where cadets may be required to process several information streams simultaneously.

The relationship between physical fitness and cognitive performance provides an important interdisciplinary perspective. Exercise-induced physiological arousal and fatigue can influence performance on cognitive tasks, suggesting that physical preparedness may interact with cognitive demands rather than operate as an independent vocational requirement [9]. Thus, physical fitness, psychological well-being, and cognitive load management should not necessarily be treated as separate student welfare concerns. They may represent interconnected conditions that influence the ability of cadets to demonstrate professional competence.

Career readiness in vocational education extends beyond the acquisition of technical knowledge. Competency-based approaches in other high-risk vocational sectors, including aviation, emphasize the integration of technical competency, practical performance, and professional development [10]. Maritime competency research similarly indicates that professional competence involves multiple interacting dimensions that contribute to safe and effective operational performance [11].

The Indonesian vocational education context also increasingly emphasizes competencies that extend beyond narrow technical knowledge. Recent research on green skills and vocational education demonstrates the growing importance of broader competency development among students and teachers [14]. Similarly, competency-needs analysis in Indonesian technical and vocational education highlights the importance of aligning educational preparation with changing professional requirements [15]. These developments provide a broader educational basis for considering maritime career readiness as a multidimensional construct.

Despite these developments, limited empirical research has examined physical fitness, mental well-being, cognitive load, and career readiness simultaneously among Indonesian maritime cadets. Existing studies generally examine these dimensions independently, while maritime education frequently treats physical training, psychological support, and simulation training as separate activities. This creates a research gap concerning whether an integrated approach can strengthen broader career readiness.

Accordingly, this study had three objectives. First, it examined the baseline levels of physical fitness, depressive symptoms, cognitive load, and career readiness among Nautika cadets at three maritime institutions in the Jakarta area. Second, it examined the relationships between these variables and career readiness. Third, it evaluated whether an eight-week integrated programme combining physical training, psychological skills development, and cognitive-load-oriented simulation produced greater improvements in career readiness than the standard curriculum.

2. Method

This study employed a two-phase sequential design. Phase 1 established baseline measurements among 180 Nautika cadets between April and September 2025. Phase 2 evaluated an eight-week integrated intervention conducted between October 2025 and January 2026.

Phase 1 involved 180 Level 2 and Level 3 Nautika cadets from three maritime institutions: AMANJAYA, AMD, and STMT Malahayati, with 60 participants recruited from each institution. Phase 2 involved 90 cadets selected from the Phase 1 sample who provided informed consent to participate in the intervention. Participants were randomly assigned to an intervention group (n=45) or a waitlist control group (n=45), with stratification by institution to maintain balanced representation. All participants were male, reflecting the Nautika cadet population at the participating institutions during the study period. The mean age was 21.4 years (SD=1.8). Ethical clearance was obtained from the research ethics committee of the lead institution and participating institutions. All participants provided written informed consent before data collection.

Physical fitness was assessed using the standardized 20-metre shuttle run test following the protocol developed by Léger et al. [12]. The test was used to estimate maximal aerobic capacity (VO_2max), expressed in ml/kg/min. A value of 38 ml/kg/min was used as the operational threshold adopted in this study for sustained watchkeeping endurance based on the occupational fitness literature [3] Mental well-being was assessed using the Patient Health Questionnaire-9 (PHQ-9) [5]. The instrument measures depressive symptoms experienced during the previous two weeks. The validated Indonesian-language version was used, and internal consistency in the present sample was α=0.84. Scores of 5–9 were interpreted as mild depressive symptoms, scores of 10–14 as moderate symptoms, and higher scores as more severe symptom levels. Participants meeting the study's referral criteria were directed toward appropriate institutional support.

Cognitive load was assessed using the Paas 9-point mental effort scale [8]. The questionnaire was administered immediately after a standardized 60-minute bridge simulation at each participating institution. Responses ranged from 1 (very low mental effort) to 9 (very high mental effort). A score of ≥7 was operationally defined as high cognitive load for the purposes of this study.

Career readiness was measured using the Maritime Career Readiness Inventory (MCRI), a 24-item instrument developed for this study. The MCRI consists of four dimensions: professional knowledge readiness, professional skills confidence, professional identity commitment, and professional resilience orientation, with six items per dimension. Items were evaluated using a five-point response scale. The instrument was reviewed by three senior Nautika lecturers and two senior maritime company training managers. The resulting content validity index was 0.86, while internal consistency was α=0.87.

The eight-week integrated wellness programme consisted of three interconnected components. The physical training component was delivered twice per week for 45 minutes per session. Each session included approximately 20 minutes of progressive aerobic exercise and 25 minutes of functional strength and flexibility exercises. Depending on institutional facilities, aerobic activities included running, cycling ergometer exercise, or swimming. The programme was designed by a sports science consultant and delivered by trained institutional physical education staff.

The mental well-being component was delivered once per week for 60 minutes. The programme included stress recognition, cognitive reframing, stress inoculation, and professional identity development. Sessions 1–2 focused on recognizing and normalizing stress; Sessions 3–4 addressed negative automatic thoughts and cognitive reframing; Sessions 5–6 used graduated exposure to maritime-specific stressors; and Sessions 7–8 focused on professional identity and commitment to sea service. The sessions were designed by a psychologist and delivered by trained institutional counsellors.

Cognitive load management was integrated into a 90-minute weekly bridge simulation session. Simulation tasks were progressively introduced, beginning with individual components such as chart reading and radar interpretation before integrating AIS, radio communication, and full-mission activities. The control group continued to receive the standard simulation curriculum.

Phase 1 data were analyzed using descriptive statistics, Pearson correlation analysis, and one-way analysis of variance (ANOVA). Pearson correlations were used to examine relationships among VO_2max, PHQ-9 scores, cognitive load, and MCRI scores. ANOVA was used to examine differences among the three participating institutions.

Phase 2 outcomes were examined using analysis of covariance (ANCOVA), with post-intervention MCRI scores as the dependent variable and baseline MCRI scores as the covariate. Between-group effects were examined for overall career readiness and individual outcome measures. Effect sizes were reported using eta squared (η^2). Statistical analyses were conducted using IBM SPSS Statistics version 26 [13].

3. Results and Discussion

Table 1 presents the baseline measurements of physical fitness, depressive symptoms, cognitive load, and career readiness among the 180 cadets. The overall mean VO_2max was 37.0 ml/kg/min, below the operational threshold of 38.0 ml/kg/min. Approximately 61.1% of cadets were below this threshold, indicating that a substantial proportion of participants had aerobic fitness levels below the criterion adopted in this study. This finding supports the importance of incorporating physical fitness into maritime vocational preparation, particularly because routine competency assessment primarily emphasizes technical and academic performance [1], [3], [4].

The mean PHQ-9 score was 5.4. Overall, 28.3% of participants obtained scores of at least 5, indicating at least mild depressive symptoms. Furthermore, 14.4% obtained scores of at least 10, corresponding to at least moderate depressive symptoms and indicating the need for appropriate institutional support. AMD recorded the highest mean PHQ-9 score (6.1), and the difference among institutions was statistically significant, $F(2,177)=4.12$, $p=.018$. Because PHQ-9 is a screening instrument, these findings should be interpreted as depressive symptom levels rather than clinical diagnoses [5].

The mean cognitive load score was 6.5, while 47.2% of participants reported scores of at least 7 during bridge simulation. This result suggests that a substantial proportion of cadets experienced high mental effort during a core vocational learning activity. From a Cognitive Load Theory perspective, excessive cognitive demands may limit the working-memory resources available for developing and integrating professional schemas [7], [8]. Table 2 presents the Pearson correlations among VO_2max, PHQ-9, cognitive load, and MCRI.

All three dimensions were significantly associated with career readiness. VO_2max showed a positive correlation with MCRI ($r=0.61$, $p<0.001$), indicating that higher aerobic fitness was associated with higher career readiness. PHQ-9 scores were negatively correlated with MCRI ($r=-0.58$, $p<0.001$), indicating that greater depressive symptom burden was associated with lower career readiness. Cognitive load was also negatively associated with MCRI ($r=-0.54$, $p<0.001$), suggesting that higher perceived mental effort during simulation was associated with lower career readiness.

The relationships among the three non-academic dimensions were also significant. VO_2max was negatively correlated with PHQ-9 scores ($r=-0.44$, $p<0.001$) and cognitive load ($r=-0.38$, $p<0.001$), while PHQ-9 scores were positively correlated with cognitive load ($r=0.41$, $p<0.001$). These findings support an integrated perspective in which physical, psychological, and cognitive conditions may interact during vocational learning.

Table 1. Baseline Physical Fitness, Mental Well-Being, Cognitive Load, and Career Readiness (n=180)

Measure	AMANJAYA (n=60)	AMD (n=60)	STMT Malahayati (n=60)	Full Sample M (SD)	Threshold/Indicator
VO_2max (ml/kg/min)	38.4 (4.8)	35.6 (5.2)	37.1 (4.9)	37.0 (5.1)	61.1% below 38.0
PHQ-9 score	4.8 (3.2)	6.1 (3.8)	5.4 (3.4)	5.4 (3.5)	28.3% ≥5
Cognitive load (1–9)	6.2 (1.4)	6.8 (1.6)	6.4 (1.5)	6.5 (1.5)	47.2% ≥7
MCRI (1–5)	3.48 (0.62)	3.21 (0.68)	3.34 (0.64)	3.34 (0.65)	—

Table 2. Pearson Correlations Among Physical Fitness, Mental Well-Being, Cognitive Load, and Career Readiness (n=180)

Variable	VO_2max	PHQ-9	Cognitive Load	MCRI
VO_2max	1	−0.44***	−0.38***	0.61***
PHQ-9	−0.44***	1	0.41***	−0.58***
Cognitive Load	−0.38***	0.41***	1	−0.54***
MCRI	0.61***	−0.58***	−0.54***	1

*Note: *** p<.001.*

The positive relationship between physical fitness and career readiness is consistent with occupational physiology research emphasizing the role of cardiovascular capacity in sustained performance [3] and with evidence concerning cardiovascular fitness among maritime cadets [4]. The association between physical fitness and cognitive load also provides a plausible physiological explanation for why physical preparedness may be relevant to bridge simulation performance. Exercise and physiological arousal can influence cognitive task performance, although the direction and magnitude of these effects depend on task characteristics and exercise intensity [9].

The negative association between depressive symptoms and career readiness indicates that psychological readiness should not be regarded as separate from professional preparation. Cadets experiencing greater psychological symptom burden may face difficulties with concentration, motivation, confidence, and adaptation to professional demands. This finding is particularly relevant to maritime education because the transition from cadet training to operational employment requires not only technical competency but also adaptation to changing professional and technological conditions [6].

The cognitive load finding is also consistent with the theoretical assumptions of Cognitive Load Theory [7], [8]. Cadets who experience excessive mental effort during simulation may have fewer cognitive resources available for situational awareness, decision-making, and communication. However, the correlational design of Phase 1 means that these relationships should not be interpreted as evidence of direct causation. In particular, the results do not establish that low physical fitness causes lower career readiness or that high cognitive load directly causes poorer professional performance. Table 3 summarizes the pre- and post-intervention measurements for the intervention and control groups.

The intervention group demonstrated improvements across all four measures. Mean VO_2max increased from 36.8 to 41.2 ml/kg/min, while the mean PHQ-9 score decreased from 5.6 to 3.8. Cognitive load decreased from 6.6 to 4.8, while MCRI increased from 3.28 to 3.87. In comparison, changes in the control group were substantially smaller.

After controlling for baseline MCRI, ANCOVA showed a significant difference in post-intervention career readiness between groups, $F(1,87)=24.83$, $p<.001$, $\eta^2=.222$. The reported effect size indicates a substantial between-group intervention effect.

Table 3. Pre- and Post-Intervention Comparison Between Intervention and Control Groups (n=90)

Measure	Intervention Pre M (SD)	Intervention Post M (SD)	Control Pre M (SD)	Control Post M (SD)
VO_2max (ml/kg/min)	36.8 (5.1)	41.2 (4.6)	37.2 (4.9)	37.8 (5.0)
PHQ-9	5.6 (3.4)	3.8 (2.9)	5.2 (3.6)	5.1 (3.5)
Cognitive load (1–9)	6.6 (1.5)	4.8 (1.4)	6.4 (1.6)	6.3 (1.5)
MCRI (1–5)	3.28 (0.64)	3.87 (0.58)	3.31 (0.66)	3.36 (0.64)

Table 4. ANCOVA Results for Post-Intervention Outcomes

Outcome	F	p-value	η^2	Effect
MCRI—Overall Career Readiness	24.83	<.001	0.222	Large
MCRI—Professional Knowledge	8.42	0.005	0.088	Moderate
MCRI—Skills Confidence	18.64	<.001	0.177	Large
MCRI—Professional Identity	22.17	<.001	0.203	Large
MCRI—Professional Resilience	26.81	<.001	0.236	Large
VO_2max	31.42	<.001	0.265	Large

Outcome	F	p-value	η^2	Effect
PHQ-9	12.84	0.001	0.129	Moderate
Cognitive Load	28.63	<.001	0.248	Large

The strongest effects were observed for VO_2max (η^2=.265), cognitive load (η^2=.248), professional resilience (η^2=.236), and professional identity (η^2=.203). The effect on professional knowledge was smaller (η^2=.088). This pattern is theoretically plausible because both intervention and control groups continued to receive the standard academic curriculum, whereas the intervention group additionally received activities specifically targeting physical fitness, psychological skills, and cognitive load management.

The improvement in professional identity and resilience is particularly important for maritime vocational education. Technical knowledge can be developed through conventional classroom and practical instruction, whereas professional identity and resilience may require repeated exposure to realistic demands, reflection, stress-management strategies, and opportunities to experience competence. This finding is consistent with competency-based education approaches that emphasize broader professional development alongside technical skills [10], [11].

The reduction in cognitive load also has implications for bridge simulation design. Rather than presenting complete operational complexity immediately, progressive integration of navigation components may provide learners with opportunities to automate component skills before managing several information streams simultaneously. Such instructional sequencing is consistent with Cognitive Load Theory and its emphasis on managing unnecessary cognitive demands during initial skill acquisition [7], [8].

The physical fitness improvement further demonstrates the potential value of integrating structured exercise into maritime education. The increase in estimated VO_2max from 36.8 to 41.2 ml/kg/min in the intervention group is consistent with exercise physiology literature showing that structured physical activity can improve cardiovascular capacity [3], [4]. The simultaneous reduction in cognitive load is also compatible with evidence that exercise-related physiological changes can influence cognitive task performance [9].

The results also have implications for the broader development of vocational education. Contemporary vocational education increasingly emphasizes competencies that extend beyond narrow technical knowledge, including adaptability and emerging professional skills [14], [15]. For maritime institutions, this suggests that career readiness can be conceptualized as a multidimensional outcome involving technical competence, physical capacity, psychological readiness, cognitive regulation, professional identity, and resilience.

Nevertheless, the results should be interpreted within several limitations. The intervention sample consisted of volunteers drawn from the Phase 1 population, and the intervention lasted only eight weeks. The study also relied partly on self-reported psychological and cognitive-load measures. In addition, the MCRI was developed specifically for this study and therefore requires further validation using larger and more diverse maritime populations. The study also did not directly measure subsequent onboard operational performance. Future research should employ longer follow-up periods, objective performance measures, and multivariate or longitudinal models to determine whether the observed improvements translate into actual operational performance during sea service.

4. Conclusion

This study demonstrates that physical fitness, mental well-being, cognitive load management, and career readiness are significantly interconnected dimensions of Nautika cadet development. At baseline, 61.1%

of cadets were below the study's operational VO_2max threshold, 28.3% reported at least mild depressive symptoms, and 47.2% experienced high cognitive load during bridge simulation. Career readiness was positively associated with physical fitness and negatively associated with depressive symptoms and cognitive load.

The eight-week integrated programme produced significant improvements in career readiness compared with the waitlist control condition, with particularly substantial effects on physical fitness, cognitive load, professional identity, and professional resilience. These findings suggest that maritime vocational education should move beyond a predominantly academic and technical model of career preparation toward a more integrated approach.

The practical implication is that structured progressive physical training should be incorporated into Nautika curricula as part of professional preparation rather than treated solely as an extracurricular activity. Bridge simulation should use progressive task integration to manage cognitive load and facilitate the automation of component skills. Psychological skills training addressing stress recognition, cognitive reframing, stress inoculation, and professional identity should also be embedded within cadet education alongside existing academic and counselling services.

The scientific contribution of this study lies in connecting physical, psychological, cognitive, and vocational dimensions within a single maritime education framework. The findings provide an empirical basis for considering career readiness as a multidimensional construct in which professional performance depends not only on what cadets know, but also on their physical capacity, psychological readiness, and ability to manage complex cognitive demands.

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