

Short communication

Evaluating the FitMáx questionnaire for fitness-to-dive assessments in a military population

Pieter D Dijk¹, Paul Clarijs¹, Thijs T Wingelaar¹

¹ Royal Netherlands Navy Diving and Submarine Medical Center, Rijkszee en Marinehaven, Den Helder, the Netherlands

Corresponding author: Dr Thijs Wingelaar, Royal Netherlands Navy Diving and Submarine Medical Center, Rijkszee en Marinehaven, 1780 CA Den Helder, the Netherlands

tt.wingelaar@mindef.nl

Keywords

Cardiorespiratory fitness; Divers; Self-reported fitness; Recompression personnel; $\dot{V}O_{2\max}$; $\dot{V}O_{2\text{peak}}$

Abstract

(Dijk PD, Clarijs P, Wingelaar TT. Evaluating the FitMáx questionnaire for fitness-to-dive assessments in a military population. Diving and Hyperbaric Medicine. 2026 30 September;56(3):361–364. doi: 10.28920/dhm56.3.361-364. PMID: 42743577.) This study evaluated the validity of the FitMáx questionnaire for estimating $\dot{V}O_{2\text{peak}}$ in 157 Dutch Navy divers and recompression personnel, a population characterised by high physical fitness and occupational demands. While self-reported questionnaires offer a logistically feasible alternative to resource-intensive direct testing, their accuracy in fitness-to-dive assessments remains unclear. Participants completed the FitMáx questionnaire prior to cycle ergometry with direct $\dot{V}O_{2\text{peak}}$ measurement. Results showed a moderate correlation ($r = 0.631$, $P < 0.001$) between mean estimated $\dot{V}O_{2\max}$ (43.7, SD 5.34 mL·kg⁻¹·min⁻¹) and mean measured $\dot{V}O_{2\text{peak}}$ (45.4, SD 6.52 mL·kg⁻¹·min⁻¹), with the questionnaire systematically underestimating fitness by 1.8 mL·kg⁻¹·min⁻¹, with a 95% confidence interval of agreement limit of ± 10.9 mL·kg⁻¹·min⁻¹, and a moderate intraclass correlation coefficient of 0.748 ($P < 0.001$). False-positive and false-negative rates were 8.9% and 10.8%, respectively, raising concerns about reliability for pass/fail decisions. Participants reported difficulties answering questions unrelated to their routine activities, potentially contributing to the observed variability. Given these limitations, including the homogeneous, highly fit sample and the inability to differentiate between subgroups, the Royal Netherlands Navy Diving Medical Center has not adopted the FitMáx for fitness-to-dive evaluations. While questionnaires may streamline large-scale assessments, direct exercise testing remains valuable for precise, individualised risk stratification in occupational diving.

Introduction

Diving imposes significant demands on the cardiopulmonary system, necessitating physiological adaptations to ensure safety and performance.¹ To our knowledge, there is no conclusive evidence establishing the minimum exercise tolerance required for safe diving. However, a general consensus suggests that higher exercise tolerance is associated with safer diving practices. Though no universal fitness standard exists, occupational fitness-to-dive assessments typically evaluate exercise tolerance, often measuring maximal aerobic fitness ($\dot{V}O_{2\text{peak}}$).²

$\dot{V}O_{2\text{peak}}$, commonly expressed in mL·kg⁻¹·min⁻¹, can be assessed through various methods.³ These methods are broadly categorised into direct and indirect approaches. Direct measurements involve a more complex setup, where participants wear a mask to measure inhaled and exhaled air, enabling precise calculation of $\dot{V}O_{2\text{peak}}$. Indirect methods estimate $\dot{V}O_{2\text{peak}}$ based on physical performance, such as the distance covered in a 12-minute run or the maximum resistance achieved on a cycle ergometer. While indirect methods are slightly less accurate than direct measurements,

both approaches require specialised equipment and resources. Furthermore, both testing procedures impose ‘domestic overhead’ on participants, such as the need to change clothing or travel to a designated facility. These requirements may introduce operational challenges, particularly when implementing such assessments at scale.

An alternative approach to assessing $\dot{V}O_{2\text{peak}}$ is the use of self-reported questionnaires, which significantly reduce the logistical and resource demands of traditional testing. However, many existing questionnaires demonstrate only moderate to poor correlations with directly or indirectly measured $\dot{V}O_{2\text{peak}}$.⁴ The recently developed FitMáx questionnaire presents a promising solution, exhibiting a very high correlation ($r = 0.94$) between measured and estimated $\dot{V}O_{2\text{peak}}$, along with excellent test-retest reliability (intraclass correlation coefficient = 0.97) in an active adult population.^{5,6}

If the FitMáx questionnaire proves valid and reliable in a diving population, it could substantially streamline occupational fitness-to-dive assessments by reducing the need for resource-intensive testing. We hypothesise that the

FitMáx questionnaire will demonstrate a strong correlation between estimated and measured $\dot{V}O_{2\text{peak}}$ in this context.

Methods

This prospective study included all Navy divers and recompression personnel that underwent a fitness-to-dive assessment at the Royal Netherlands Navy Diving and Submarine Medical Center between 1 January 2025 and 30 June 2025. This study was approved by the Surgeon General of the Netherlands Armed Forces (ref: DOSCO2025013218). Even though in the Netherlands medical ethical review is not required for studies only including short questionnaires, the Declaration of Helsinki and European General Data Protection Regulation were adhered to.

Participation was entirely voluntary, with informed consent in writing, and had no effect on the medical assessment of the diver or career of the participant. Prior to cycle ergometry, which is a standard part of fitness-to-dive assessments in the Royal Netherlands Navy, subjects were asked to fill in a paper version of the FitMáx questionnaire, which asks about the sex, age, height and weight of the subject, as well as three questions regarding the estimated distance and speed the subject can walk/run, cycle and climb stairs. The questionnaire was collected by the researchers, and neither the subject's participation in the study nor the questionnaire results were disclosed to the physician conducting the medical assessment. Afterwards, the subject performed a cycle ergometry with a ramp protocol and direct measurement of the inhaled and exhaled breath using the Vyntus™ CPX metabolic cart and SentrySuite™ software package (Jaeger Medical, London ON, Canada). Data from the ergometry, including max heartrate, max resistance and peak oxygen consumption were recorded. From the answers of the FitMáx questionnaire, a $\dot{V}O_{2\text{peak}}$ can be calculated through an algorithm, which was done after the fitness-to-dive assessment by an independent researcher. From here on, we refer to the score of the FitMáx questionnaire as $\dot{V}O_{2\text{max}}$, and use $\dot{V}O_{2\text{peak}}$ for directly measured ergometry.

All data from the questionnaire, as well as parameters associated with the direct ergometry performed, were entered into a database. The difference between the estimated $\dot{V}O_{2\text{max}}$ and measured $\dot{V}O_{2\text{peak}}$ were tested using a paired samples *t*-test, and correlation was calculated using a Pearson's correlation coefficient. Additionally, Bland-Altman limits of agreement and intraclass correlation coefficients (ICC) were calculated. All statistical analyses were performed using SPSS version 31.0. Statistical significance was assumed at $\alpha < 0.05$.

Results

In total 157 Navy divers and hyperbaric personnel were included, with the following baseline parameters: median age 34.0 years (interquartile range [IQR] 28.0–41.0), mean

height 182.6 cm (standard deviation [SD] 8.3), mean weight 86.3 kg (SD 11.8), and 93% were male.

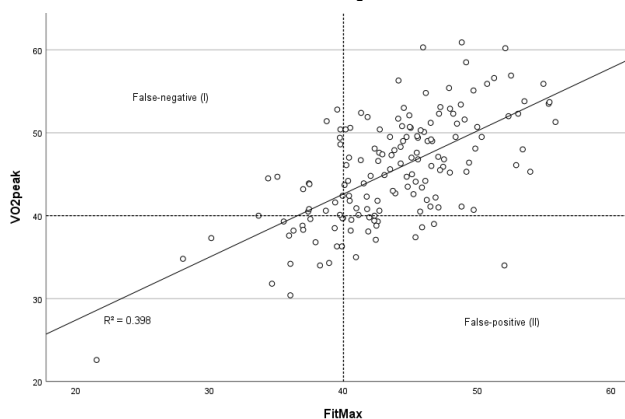
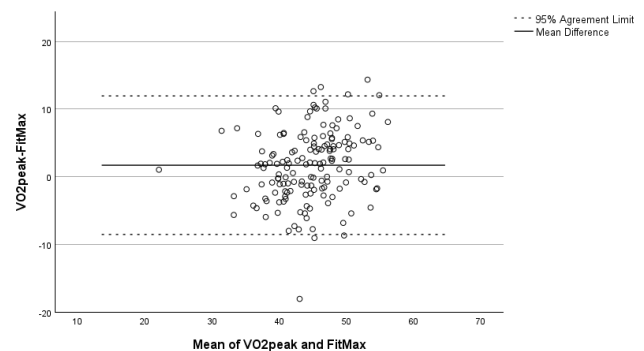
Cycle ergometry parameters included a median maximal heartrate of 180 beats per minute [IQR 173.3–186.0], median maximum resistance of 320 W [IQR 283–352], and median respiratory exchange ratio (RER) of 1.18 [IQR 1.14–1.25], all indicating that end of test criteria were met. Mean measured $\dot{V}O_{2\text{peak}}$ was $45.4 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ (SD 6.52), which was statistically significantly higher than the FitMáx estimated $\dot{V}O_{2\text{max}}$ of $43.7 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ (SD 5.34) ($t = 4.310$, $P < 0.001$). The correlation between the two variables was 0.631 ($P < 0.001$), i.e., $R^2 = 0.398$, as illustrated in Figure 1. The 5% trimmed mean difference between the two parameters was -1.8 (SD 5.2), with a range of -14.4 to 18.0 . The Bland-Altman analysis (Figure 2) shows a 95% confidence interval of agreement limits of $\pm 10.9 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. A moderate to good degree of reliability was found between 157 measurements, with an average ICC of 0.748 with a 95% confidence interval from 0.636 to 0.823 ($F = 2.474$, $P < 0.001$).

In 34 subjects (21.7%) the $\dot{V}O_{2\text{peak}}$ was lower than $40 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. The FitMáx questionnaire correctly estimated the $\dot{V}O_{2\text{peak}}$ to be lower than $40 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ in 58.8% of the cases, meaning that 14 cases (8.9% of the total population) the FitMáx would have incorrectly estimated sufficient exercise tolerance (false-negative, upper left quadrant of Figure 1). Conversely, in 17 subjects (10.8% of the total population) the estimated $\dot{V}O_{2\text{max}}$ was lower than $40 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, while the measured $\dot{V}O_{2\text{peak}}$ was higher than 40 (false-positive, lower right quadrant of Figure 2).

Discussion

The measured $\dot{V}O_{2\text{max}}$ correlates moderately ($R^2 = 0.398$) to the FitMáx estimated $\dot{V}O_{2\text{peak}}$. The latter underestimated the fitness of the population by approximately $1.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, with a 95% confidence interval of agreement limits of $\pm 10.9 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, and a moderate to good reliability (ICC = 0.748).

Based on our sample, the correlation between estimated and measured $\dot{V}O_{2\text{max}}$ is lower than earlier reported. Even though this difference is approximately 4% on a group level, the individual variation is considerable. Wide individual variation has been found in previous studies assessing cardiopulmonary exercise tolerance in military populations.⁷ Some subjects reported that they found it hard to answer some questions of the FitMáx, for instance how many stairs they would be able to climb or at what speed they would be able to cycle continuously for one hour, if these activities were not part of their daily life. While this may also be the case for the population on which the questionnaire has been validated, this could be a possible explanation of the lower correlation and wider spread of our results.

Figure 1Correlation between $\dot{V}O_2\text{max}$ estimated by FitMáx and measured $\dot{V}O_2\text{peak}$ **Figure 2**Bland-Altman plot of differences; $\dot{V}O_2\text{max}$ estimated by FitMáx vs measured $\dot{V}O_2\text{peak}$ 

Questionnaire-based assessments of $\dot{V}O_2\text{peak}$ are widely used in occupational medicine and have demonstrated moderate to strong correlations with measured exercise tolerance.⁸ However, few studies have evaluated their validity in military populations or considered their utility when rendering a ‘verdict’, such as pass/fail fitness-to-dive assessments. A false-negative and false-positive percentage of 8.9% and 10.8%, respectively, would introduce considerable noise in exercise tolerance tests as part of fitness-to-dive assessments. This has significant consequences for diving safety, at least in a military context. How this would shift if the FitMáx questionnaire would have been used in isolation, i.e., without being followed with direct ergometry as is the current practice, is hard to predict. However, we feel that subjects could be inclined to overestimate their physical performance, as being fit to dive also has financial consequences for occupational divers as it affects their fitness-to-dive status. Conversely, if the subject would want to deliberately fail this assessment, for instance in rapid mobilisation where not every subject may be motivated to partake in operational diving activities, it would have been easier to incorrectly answer a questionnaire than to feign reaching one’s exercise tolerance in a direct or indirect test.

Many of the limitations outlined above also apply to the use of questionnaires for assessing cardiopulmonary exercise tolerance. Moreover, direct exercise testing offers additional insights, such as detailed analysis of breathing patterns, cardiac rhythm, and personalised recommendations for physical training.⁹ However, such testing requires specialised equipment, trained personnel, and significant time, which may be impractical in scenarios involving large-scale assessments, such as the rapid evaluation of candidates during military mobilisation. Indirect field assessments, such as multi stage shuttle tests or other submaximal protocols, or more practical approaches like a swimming test, may be more feasible in these scenarios, allowing assessment of large numbers of recruits while minimising the logistic burden on the system. Furthermore, the financial burden of

direct testing may render it unsuitable for recreational divers. However, in recreational diving many of these limitations are nonexistent. In these contexts, validated questionnaires, or a ‘staged approach’, e.g., where the FitMáx questionnaire could be used to determine whether a subject requires exercise testing for the fitness-to-dive assessment, may serve as a pragmatic alternative, balancing feasibility with clinical utility.

Given these considerations, the Royal Netherlands Navy Diving Medical Center has not incorporated the FitMáx questionnaire into its fitness-to-dive evaluation protocol. Future iterations of the FitMáx, or other questionnaires designed to estimate $\dot{V}O_2\text{peak}$, will be assessed for potential usage.

LIMITATIONS

First, this study was conducted among military personnel, a population characterised by a predominance of young, physically fit males. As such, the findings may not generalise to other diving populations, such as recreational divers. Caution is therefore warranted when extrapolating these results to broader or distinct groups.

Second, although the study included a substantial sample size, the resolution was insufficient to differentiate between subgroups, such as divers versus recompression personnel or varying age cohorts, among whom the questionnaire’s validity may differ. Future research could explore subgroup-specific performance to refine the algorithm and improve its applicability.

Lastly, while the moderate correlation observed may have been influenced by outliers, excluding these individuals would enhance statistical validity at the group level but fail to improve clinical utility for individual assessments. The primary objective of fitness-to-dive evaluations is to identify at-risk individuals, and we believe that complex statistical adjustments are not appropriate with this practical aim in mind.

Conclusions

FitMáx demonstrated moderate correlation ($R^2 = 0.398$) with measured $\dot{V}O_{2\text{peak}}$ in military divers but underestimated fitness ($\sim 1.8 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) with a 95% confidence interval of agreement limit of $\pm 10.9 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, a moderate to good reliability ($\text{ICC} = 0.748$). A misclassification rate of 9.8% false-negative and 10.8% false-positive, combined with the aforementioned test characteristics and potential self-reporting biases, render it insufficiently precise for fitness-to-dive evaluations in military divers. Future research could refine questionnaire-based tools to improve accuracy or expand to other domains, such as recreational diving.

References

- 1 Bosco G, Rizzato A, Moon RE, Camporesi EM. Environmental physiology and diving medicine. *Front Psychol.* 2018;9:72. doi: 10.3389/fpsyg.2018.00072. PMID: 29456518. PMCID: PMC5801574.
- 2 Wendling J, vanden Eede R, Elliott DH, Meintjes J, Méliet J-L, Nome T, editors. Medical assessment for work under pressure – EDTC Fitness to dive standards. 2nd ed. London, UK: International Marine Contractors Association; 2024.
- 3 Lee J, Zhang XL. Physiological determinants of $\dot{V}O_{2\text{max}}$ and the methods to evaluate it: A critical review. *Sci Sports.* 2021;36:259–71. doi: 10.1016/j.scispo.2020.11.006.
- 4 Schembre SM, Riebe DA. Non-exercise estimation of $\dot{V}O_{2\text{max}}$ using the International Physical Activity Questionnaire. *Meas Phys Educ Exerc Sci.* 2011;15:168–81. doi: 10.1080/1091367X.2011.568369. PMID: 21927551. PMCID: PMC3173948.
- 5 Meijer R, van Hooff M, Papen-Botterhuis NE, Molenaar CJL, Regis M, Timmers T, et al. Estimating $\dot{V}O_{2\text{peak}}$ in 18–90 year-old adults: Development and validation of the FitMáx©-questionnaire. *Int J Gen Med.* 2022;15:3727–37. doi: 10.2147/IJGM.S355589. Erratum in: *Int J Gen Med.* 2025;18:6091–4. doi: 10.2147/IJGM.S565126. PMID: 35411174. PMCID: PMC8994663.
- 6 Meijer R, Schep G, Regis M, Papen-Botterhuis NE, Savelberg HHCM, van Hooff M. Test-retest reliability of the FitMáx©-questionnaire in a clinical and healthy population. *J Patient Rep Outcomes.* 2024;8(1):3. doi: 10.1186/s41687-023-00682-9. PMID: 38175456. PMCID: PMC10767039.
- 7 Santtila M, Häkkinen K, Pihlainen K, Kyröläinen H. Comparison between direct and predicted maximal oxygen uptake measurement during cycling. *Mil Med.* 2013;178:234–8. doi: 10.7205/milmed-d-12-00276. PMID: 23495472.
- 8 Matsuo T, So R, Takahashi M. Workers' physical activity data contribute to estimating maximal oxygen consumption: a questionnaire study to concurrently assess workers' sedentary behavior and cardiorespiratory fitness. *BMC Public Health.* 2020;20(1):22. doi: 10.1186/s12889-019-8067-4. PMID: 31914965. PMCID: PMC6950791.
- 9 Koutlianos N, Dimitros E, Metaxas T, Cansiz M, Deligiannis A, Kouidi E. Indirect estimation of $\dot{V}O_{2\text{max}}$ in athletes by ACSM's equation: valid or not? *Hippokratia.* 2013;17(2):136–40. PMID: 24376318. PMCID: PMC3743617.

Conflicts of interest and funding: nil

Submitted: 16 April 2026

Accepted after revision: 25 July 2026

Copyright: This article is the copyright of the authors who grant *Diving and Hyperbaric Medicine* a non-exclusive licence to publish the article in electronic and other forms.