Prediction of stress level in military submariners, based on physical conditioning and sleep quality variables

Predicción del nivel de estrés en submarinistas militares, en base a variables de acondicionamiento físico y calidad del sueño

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Abstract. The objective of the study was to predict the level of stress in military submariners based on physical fitness and sleep quality variables. Cross-sectional and correlational research, with a sample of 40 male submarines (28.70±3.98 years old). Body mass and composition data were analyzed (MCT), height, BMI, waist, body fat (%G), dominant handgrip (PMDom), cardiorespiratory fitness (VO2max), squats, sit-ups, relative power of lower limbs (PotRel MMII), stress (PSS-10), Epworth Sleepiness Assessment (ESE) and Pittsburgh Sleep Quality Index (PSQI). Overall, negative associations (p<0.05) were observed between VO2max and MCT, BMI, %BF, and waist; PotRel MMII and age and %BF; squat and %GI; sit-up and MCT, BMI, %BF and waist; and finally, stress and VO2max and sit-up. Furthermore, positive associations (p<0.05) between BMI and MCT; %BF and MCT and BMI; waist and age, BMI, MCT, and %BF; squats and PMDOM, VO2max and PotRel MMII; sit-ups and VO2max, PotRel LL and squats; ending with PSQI and stress. Furthermore, among the stress level prediction equation models developed, the equation Stress=15.92+1.538(PSQI)-0.497(VO2max)+0.188(Squat) met the proposed requirements, which is based on sleep quality, cardiorespiratory fitness, and number of squats.

Keywords: Submariner; stress, physical fitness, sleep quality, military personal.

Resumen. El objetivo del estudio fue predecir el nivel de estrés en submarinistas militares en función de variables de condición física y calidad del sueño. Investigación transversal y correlacional, con una muestra de 40 submarinistas masculinos (28.70±3.98 años). Se analizaron datos de masa y composición corporal (MCT), altura, IMC, cintura, grasa corporal (%G), agarre manual dominante (AMDom), aptitud cardiorespiratoria (VO2max), sentadillas, abdominales, potencia relativa de miembros inferiores (PotRel MMII), estrés (PSS-10), Evaluación de la somnolencia de Epworth (ESE) e Índice de calidad del sueño de Pittsburgh (PSQI). En general, se observaron asociaciones negativas (p<0.05) entre el VO2max y el MCT, el IMC, el %G y la cintura; PotRel MMII y edad y %G; sentadilla y %G; abdominales y MCT, IMC, %G y cintura; y finalmente, estrés y VO2max y abdominales. Además, se encontraron asociaciones positivas (p<0.05) entre IMC y MCT; %G y MCT e IMC; cintura y edad, IMC, MCT y %G; sentadillas y AMDom, VO2max y PotRel MMII; abdominales y VO2max, PotRel MMII y sentadillas; terminando con PSQI y estrés. Además, entre los modelos de ecuaciones de predicción del nivel de estrés desarrollados, la ecuación Estrés=15.92+1.538(PSQI)-0.497(VO2max)+0.188(Squat) cumplió con los requisitos propuestos, la cual se basa en la calidad del sueño, la aptitud cardiorespiratoria y el número de sentadillas.

Palabras clave: Submarinista; estrés, condición física, calidad del sueño, personal militar.

Introduction

Job characteristics of submariners are of an unusual, confined, and isolated nature (Martin-Krumm et al., 2021; Van Puyvelde et al., 2022). Possible changes in the health of soldiers exposed to this environment may come from a sedentary lifestyle, sleep deprivation, and even high levels of stress (Kang & Song, 2018; Miranda et al., 2022). During a mission, the vessel can be submerged for weeks, with submariners operating in restricted environments that involve unusual stimuli, such as changes in circadian rhythm (Van Puyvelde et al., 2022), monotonous environment (Martin-Krumm et al., 2021), deprivation of natural light (Van Puyvelde et al., 2022), shift work (Duplessis et al., 2007), among others. In this sense, Trousselard et al. (2015) noted an increase in negative mood, a deterioration in positive mood, and less restorative sleep among its crew. Margel et al. (2003) monitored the sleep of a submarine crew and found a total sleep time below average and recommended levels during a patrol. Already, Pawar et al. (2007) reported high occupational stress in 7.7% of their submariners. At appropriate levels, stress can be a positive element, offering the individual better conditions to react and make decisions. However, it can cause serious damage to the integrity of individuals when a certain limit is exceeded (Silva et al., 2015). In this way, physical, cognitive, psychological, and social consequences can be observed, such as low immunity, headaches, difficulty learning and concentrating, problems with sleep quality, social isolation, and relationship difficulties. (Tricoli, 2010). These changes can be enhanced when associated with a decrease in the crew’s physical fitness levels, or even a possible sedentary lifestyle (Silva et al., 2015).

The recommendation for an active lifestyle is to perform physical activity 5 days a week at moderate intensity, or a combination of moderate to high intensity 3 to 5 days a week. (American College of Sports Medicine, 2021). However, work activities in restricted environments reduce the possibility of movement and thus can accentuate a sedentary lifestyle and its associated harmful effects, such as cardiovascular, psychological, or sleep-related problems. (Fernando et al., 2023; Martin-Krumm et al., 2021;...
Vázquez et al., 2023). The consequences can be particularly harmful, and it is important to know how the individual is doing before the mission and provide recovery after it.

The study of physical valences, in general, is important for understanding physical fitness and its interactions with specific work activities, both those related to health (body composition, flexibility, muscular strength, muscular endurance and cardiorespiratory fitness), and related to performance (speed, power, agility, coordination and balance etc.) (Cunningham et al., 2018; Dudley et al., 2023).

Practicing regular physical exercise on board a submarine can be a strategy for maintaining physical fitness and reducing the level of stress produced by work activities in a restricted environment. In this way, the research into the psychophysiological variables of these individuals can promote an improvement in the working conditions of this population due to the identification of determining factors to avoid accidents, reduce stress, and improve health and quality of life. Therefore, the objective of this study was to predict the level of stress in military submariners based on physical conditioning and sleep quality variables.

Methods

This research is cross-sectional and correlational with the development of a model to predict the stress level of submariners. The study was approved by the Research Ethics Committee of Hospital Naval Marcílio Dias with CAAE number 60399822.7.0000.5256, by the guidelines of the National Health Council. Study participants signed an Informed Consent Form.

The study was carried out in 2023 with a convenience sample of 40 submariners (male) from the Brazilian Navy. This sample represents approximately forty percent of Brazilian submariners. Height and total body mass (TB) measurements were recorded (digital scale with a stadiometer, Cescorf, Brazil), waist circumference (metallic measuring tape, Cescorf, Brazil), and skinfolds of the chest, abdomen, and thigh (Premier scientific adipometer, Cescorf, Brazil). From these measurements, the percentage of body fat (%BF) was estimated. (Jackson AS, 1978).

To measure cardiorespiratory fitness, the Cooper 2400m running test was applied on a 400mths athletics track to obtain maximum oxygen consumption (VO2 max) (Cooper, 1977). To assess upper limb muscle strength, the maximum measurement of the dominant hand in the handgrip test was used (PMDom) using a dynamometer (Jamar, Sammons Preston, USA) (Marins, JCB; Giannichi, 2003). In evaluating the relative power of the lower limbs (PotRel LL), the average of five countermovement jumps was used, with an interval of 15 seconds between them (contact mat and Elite Jump System software, Celise, Brazil) (Bratz et al., 2010). Sit-up tests and squats were also performed with maximum results in 2 minutes (Marins, JCB; Giannichi, 2003).

To assess the level of stress, the Perceived Stress Scale (PSS-10) validated for Portuguese was used. (Cohen, S., Kamarck, T., Mermelstein, 1983; Luft et al., 2007). The drowsiness and sleep quality were assessed using the Epworth Sleepiness Scale (ESE) (Johns, 1991), translated and validated into Portuguese (Bertolazi AN., 2008) and the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989), respectively. For all questionnaires, the result of the sum of the items was considered.

The analysis of sample characterization data included measures of central tendency and dispersion (mean, standard deviation, minimum and maximum values). Data normality was checked using the Shapiro-Wilk test. The associations between the study variables were analyzed using the c-test Pearson correlation. To develop the equation model to estimate the level of stress, the multiple linear regression test was used, adopting the forward stepwise method to select predictor variables for the model. The reliability of the model was measured by the adjusted coefficient of determination (R2adjust) and the standard error of estimate (EPE). The paired t-test was used between the stress observed by the questionnaire and the predicted stress. Pearson's correlation coefficient was applied to analyze the relationship between observed and estimated stress levels. The analyses were carried out using the IBM SPSS Statistics 25 statistical software, adopting p<0.05 for statistical significance.

Results

Table 1 describes the sample characterization results for all variables analyzed in the study. On average, individuals with a good %BF and waist circumference below the cutoff point for increased risk of developing cardiovascular diseases (≥102cm), even with a BMI classified as overweight. A good maximum oxygen volume for age group and gender. Furthermore, the average scores of the questionnaires indicated average drowsiness, poor sleep quality, and perceived stress levels considered above average.

![Table 1. Sample characterization (n=40)](https://example.com/table1.png)
The correlation analysis between the variables of interest is presented in Table 2. Negative associations (p<0.05) were observed between VO2max and BMI, %BF, and waist; PotRel LL and age and %BF; squat and %BF; sit-ups and BMI, %BF and waist; and finally, stress and VO2max and sit-ups. Furthermore, positive associations (p<0.05) between BMI and TBM; %BF and BMI and TBM; waist and age, BMI, TBM and %BF; squats and PMDom, VO2max and PotRel LL; sit-ups and VO2max, PotRel LL and squats; and with PSQI and stress.

Table 3 presents the stress level prediction equation models developed for the variable selection criteria. For the model choice condition, the conditions of highest R, R2, R2Adj and lowest EPE were adopted. Thus, in model 3 the equation Stress = 15.92 + 1.538(PMDom) - 0.497(VO2max) + 0.188(Squat) met the proposed requirements, having as predictor variables sleep quality, maximum oxygen volume, and the number of squats performed.

After choosing the model, the estimated stress level was calculated. There was a positive correlation between observed stress and estimated stress (p<0.001), and the values found did not differ from each other (p>0.05), as shown in Table 4. The linear regression between observed and estimated stress levels is illustrated in Figure 1.

Table 2. Correlation between variables of physical conditioning, stress, and sleep quality of Brazilian submariners

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson r</th>
<th>p-value</th>
</tr>
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<tr>
<td>TBM</td>
<td>0.24</td>
<td>0.13</td>
</tr>
<tr>
<td>BMI</td>
<td>0.21</td>
<td>0.89*</td>
</tr>
<tr>
<td>%G</td>
<td>0.28</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Waist</td>
<td>0.31*</td>
<td>0.91*</td>
</tr>
<tr>
<td>PotRel LL</td>
<td>0.04</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Squat</td>
<td>0.05</td>
<td>0.30</td>
</tr>
<tr>
<td>Sit-up</td>
<td>0.11</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Stress</td>
<td>-0.14</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PSQI</td>
<td>0.04</td>
<td>0.18</td>
</tr>
<tr>
<td>VO2max</td>
<td>0.74</td>
<td>0.10</td>
</tr>
<tr>
<td>%BF</td>
<td>0.07</td>
<td>&lt;0.01</td>
</tr>
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Table 3. Stress prediction equation models for selection criteria

<table>
<thead>
<tr>
<th>Equation</th>
<th>R</th>
<th>R2</th>
<th>R2Adj</th>
<th>EPE</th>
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<tbody>
<tr>
<td>1 Stress=4.486+1.785(PSQI)</td>
<td>0.36</td>
<td>0.32</td>
<td>0.30</td>
<td>6.40</td>
</tr>
<tr>
<td>2 Stress =21.644+1.656(PSQI)-0.371(VO2max)</td>
<td>0.67</td>
<td>0.44</td>
<td>0.41</td>
<td>5.85</td>
</tr>
<tr>
<td>3 Stress = 15.92 + 1.538(PMDom) - 0.497(VO2max) + 0.188(Squat)</td>
<td>0.71</td>
<td>0.50</td>
<td>0.46</td>
<td>5.61</td>
</tr>
</tbody>
</table>

Figure 1. Linear regression between observed and estimated stress levels for Brazilian submariners. Source: author

Discussion

The study aimed to predict the level of stress in military submariners based on physical fitness and sleep quality variables. Stress in military personnel in general is reported in the literature (Bookwalter et al., 2020; Goldbach et al., 2023; Maglione et al., 2022), as well as specifically in submariners (Brasher et al., 2010, 2012; Eid & Johnsen, 2002). Concern for the health of this population is due, in part, to occupational factors, however, lifestyle behaviors play an important role (Sergi et al., 2023).
Regarding the results of the correlation among the physical fitness, stress, and sleep quality variables, the body composition variables were the most associated with the other fitness variables, both positively and negatively. The systematic review analyzing the tactical population (firefighters, police, and military) by Sergi et al. (2023) corroborates this information; increased BMI associated with decreased VO2max (Houck et al., 2020), lower muscular resistance (Maglione et al., 2022), greater muscular strength and power, but negatively associated with speed and agility (Ritabile et al., 2010).

About the stress predictor variables found in the selected equation model, sleep quality, VO2max, and number of squats were included. The relationship between sleep quality and stress is also reported in the review by Schlottz (2019). An important variable, as the author found that inadequate sleep before exposure to stress impaired the hypothalamic-pituitary-adrenal response to increased cortisol.

The results found regarding VO2max in the prediction are reinforced in the literature (Andrew Steptoe, Jennifer Moses, Andrew Mathews, S. E., 1990). Aerobic fitness, Physical Activity, and Psychophysiological Reactions to Mental Tasks. Psychophysiology, 27(3), 264–274.


**Conclusion**

The model for predicting the level of stress in military submariners was based on sleep quality, cardiopulmonary fitness, and quantity of squats. Improving physical fitness can reduce the level of stress within a restricted work environment such as a submarine, and at the same time, this indicates that it can be a strategy to minimize the effects of stress on the quality of life of this population. Future research is suggested that intends to continue the initial exploration, to support the reduction of stress and the improvement of the operational quality of the submariner population.

**References**


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