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Accuracy of a free diving mask for measuring heart rate and oxygen saturation

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INTRODUCTION:
Apnea is a sport in which ventilation is stopped in order to push your limits by staying underwater for as long as possible (static or dynamic). With ventilation cut off, the only available source of oxygen is the one present in the blood. Measuring oxygen saturation in the blood (SPO2) is therefore very important for assessing the health of divers and ensuring their safety (1). Freedivers SPO2 can drop to 50% before risking their lives (2, 3). Because of the extreme difficulty of taking measurements under water, very few sensors are suitable for measuring SPO2 combined with heart rate data (HR) (4). In addition, the available ones are often not very easy to use (5,6). In 2023, Oxama company has developed a connected mask that measures HR, SPO2 and indicates the rest time between apneas. This new tool could be a real help for athletes to minimize health risks and increase their performance. It is therefore important to check the accuracy of the mask compared with the gold standard (chest belt and oximeter).
METHODS:
16 participants with no experience in apnea aged between 18 and 25 and with similar skin color (4,7,8) took part in the study. Two experiments were carried out 48 hours apart to avoid fatigue effects. Subjects were fitted with a chest belt (Polar H10) to measure HR, a finger pulse oximeter (Sanokin) to measure SPO2, and the connected face mask (Oxama) also measuring HR and SPO2 (sampling rate 10Hz). The tests were all carried out on a cycling ergometer (Garmin) to limit movement artifacts (4,8,9). The first trial was an incremental test to identify the variations in HR and SPO2 data as a function of intensity. The subject pedals at a power of 50W for 1min30, then the power increases by 20W every 1min30 up to 190W (8 steps). The second test analyzed the variations in HR and SPO2 data under an incremental test with apnea periods. Subjects then repeated the same incremental test as the first step, but with apnea periods of 30s at the end of each stage. The test stopped when the subject could no longer keep the 30s of breath hold or when the 190W limit was achieved. To assess the reliability and accuracy of the HR and SPO2 sensors, the absolute error, Bland Altman diagram and intra-class correlation coefficients were calculated.
RESULTS:
As expected the results show that SPO2 falls at the end of apnea periods. This result is consistent with the literature (5). When mask data increases or decreases, those of the reference measurement tools increase or decrease respectively.
CONCLUSION:
HR and SPO2 follow the same trend with the mask as with the reference measurement tools, which is very encouraging. The differences in values are probably due to the different locations of the measurements (finger or face). Further testings will be conducted underwater to ensure the mask's reliability in ecological conditions.
[1] Mulder 2023/ [2] Ferretti 2001/ [3] Schagatay 2019/ [4] Hermand 2019/ [5] Kuch 2010/[6] Mulder 2021 / [7] Scherbina 2017/ [8] Zhang 2020/[9] Climstein 2020

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