28th ECSS Anniversary Congress, Paris/France, 4-7 July 2023

Wearable pressure sensors for swimming thrust analysis: a validation study

Coloretti, V., Russo, G., Fantozzi, S., Cortesi, M.

Alma Mater Studiorum, Università di Bologna

INTRODUCTION:
The swimmer can increase his velocity by decreasing hydrodynamic resistance and/or increasing thrust force (1). To assess thrust force, indirect techniques (video-based analysis or computational fluid dynamic) are more time-consuming than direct ones (tethered swimming with load cell or pressure sensors system). According to Takagi et al. (2), the pressor sensor systems calculate the forces exerted through the hands surface (A) as F = A • Pdiff where Pdiff is the hydrodynamic pressure (PD) difference between the palmar and dorsal side excluding the hydrostatic pressure influence (PS). Due to the greater ecological features of modern wearables technologies, this study aims to validate the first wireless pressure sensor system in terms of PS and PD accuracies compared with theoric static pressure (tPS) and theoric dynamic pressure (tPD).
METHODS:
The validation was conducted as: i) PS vs. tPS (calculated as P = Patm + • g • h) through the static immersion of the wearable pressure sensor (SEAL, Platysense) down to a depth of 34 cm with a constant step of 1cm; ii) PD vs. tPD (calculated as P = 0.5 • • v2) by towing 4 SEALs using an electromechanical towing system at constant velocities of 0.5, 1.0, 1.6, 1.9 ms-1 and constant depth of 10 cm. Bidimensional video analysis was used to confirm the correct depth. Within-trials (3 trials), between-sensor (10 sensors), and day-by-day reliability (2 days for 6 sensors) were analyzed in terms of ICC, CV%, TE, SEM, and MDC. Bias, standard error of estimate (SEE) and T-test/ANOVA were calculated to test the accuracy for PS and PD considering the theoric gold standard. The sensitivity of the pressure sensor was 0.1 KPa.
RESULTS:
PS showed excellent agreement for within-sensor, between-sensor, and day-by-day reliability regarding ICC (0.99, 0.99, >0.96), CV% (0.1, 0.1, 0.2), TE (0.1, 0.1, 0.1 KPa), SEM (0.1, 0.1, 0.1 KPa), and MDC (0.1, 0.1, 0.4 KPa). No differences (p < 0.05) were found between PS and tPS and between PD and tPD. Small bias and small SEE were found for PS vs. tPS (0.2 KPa and 0.1 KPa, respectively), which increase with depth according to the equation PS = 0.968 • tPS + 3.182. Furthermore, PD vs. tPD comparisons revealed a small bias at each different velocity (0.3, 0.1, 0.3, 0.4 KPa).
CONCLUSION:
The present results suggest that hydrostatic and hydrodynamic pressures acquired by wearable wireless devices demonstrate a small amount of error compared to theoric pressures, despite its increases as a function of depth (always lower than 0.4 %). The proposed instrument seems suitable for future studies in swimming propulsion analysis due to its ecologic features and lower impact on swimming technique.

REFERENCES
1) Gatta, Cortesi & Zamparo. Plos One; 2016
2) Takagi & Sanders. The engineering of sport; 2002

Topic: Biomechanics

Presentation Oral