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For competitive swimmers with a physical disability, the ideal stroke for crawl swimming has not yet been clarified, and it may be different from that of able-bodied swimmers because of differences in body structure. The objective of this study was to solve computationally the fastest arm stroke of crawl swimming for swimmers with bilateral transfemoral amputation, and to investigate the features of the optimal stroke. The optimal stroke was obtained by the optimization method with Particle Swarm Optimization (PSO) and the swimming human simulation model (SWUM). In this method, the design variables were the joint angles of the upper limbs, and the objective function was to maximize swimming speed. The optimal stroke was obtained for each stroke cycle of 0.8 s to 1.5 s with increments of 0.1 s. In addition, it was also obtained for several palmar flexion angles of the wrist at the catch phase. The fastest stroke was obtained when the stroke cycle was 1.0 s and the palmar flexion angle was 35 degrees. For short stroke cycles, the optimal stroke was the motion pulling and pushing the water near the mid-line of the trunk. For long stroke cycles, the optimal stroke was the motion pushing the water toward the outside of the trunk. In both strokes, the water was pulled and pushed shallowly. Possible reason for these features was that the optimal strokes were the solutions to reduce the torque which sinks the lower body and to stabilize the posture.

Oral-29

Swimming speed in men's 100-m Freestyle confirms the fairness of the Paralympic classification system: a meta-analysis

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Despite an increase in popularity of Paralympic sports, there is a lack of studies on these sports, and controversies regarding the classification system for Paralympian swimmers. The Paralympic classification system features 10 classes to provide fair competition for swimmers with a physical disability. The summary of the clean swimming speed (SS) can provide useful information for the classification system in competitive swimming. The aim of this study was to summarize evidence of the fairness of Paralympic categories of male swimmers with a physically disability, focusing on SS in the 100-m front crawl. Multiple databases (PubMed, EMBASE, ISI Web of Knowledge, SPORTDiscus, Academic Search Premier, CINAHL) were examined for observational studies published until October 2017, on official swimming races. Five studies were found and analyzed (n = 369; national and international level). The random effects model was used for this meta-analysis. Statistical heterogeneity among the studies was assessed by the inconsistency test (I2) and alfa = 0.05. Subgroup analyses were performed with addition of the "class" covariant according to the characteristics of the studies. Bias was analyzed with a forest plot on the OpenMeta[Analyst] software. Increases in SS were related to higher Paralympic classes. Pooling data from all studies and classes, the estimated mean of SS was 1.25 m.s-1, SD = 0.05 m.s-1, $p < 0.01$, I2 = 99%, $p < 0.01$. The analysis of sub-groups found high heterogeneity (I2 > 75%, $p < 0.05$). The results suggest that the Paralympic Classification System seems to be fair for the men's 100-m freestyle events. Assessment of studies by close classes and by groups with many classes together, e.g. S1 – S10, increased the heterogeneity of the analysis. However, further studies are necessary to explain possible inconsistencies in the Paralympic Classification.

Oral-30

Active drag of swimmers with physical impairments

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The resistance experienced by a body when it moves through the water while holding a fixed body position is termed passive drag (PD). Oh et al. (2013) found that in para swimmers, as the severity of swimming-specific impairment decreased, so did PD. Active drag (AD) is the resistance experienced when performing a swimming stroke. In able-bodied swimming, AD is more dependent on swimming technique than on anthropometry (Kolmogorov & Duplishcheva, 1992). Hollander et al. (1985) found no relationship between AD and freestyle performance of competitive able-bodied swimmers. To date, no published studies have reported the AD of para swimmers. Information on how physical impairment affects AD should be of value to swimming teachers, coaches and classifiers. The purpose of this study was to establish the relationship between AD, freestyle performance and level of impairment of para swimmers. Participants were seventy-two para-swimmers with physical impairments from IPC class S1 to S10. AD at their maximal freestyle swimming speed (SSmax) was estimated using the Naval Architecture Based Approach (NABA), an over-speed towing method (Webb et al., 2011). PD was measured directly from the towing force. The lowest drag scores from three trials were analysed. AD was normalised for SSmax and body mass, BM (ADnorm = AD/BM/SSmax^2). PD was similarly normalised (PDnorm). SSmax ranged from 0.21–1.75 m/s. PD and AD ranged from 2.8–123.6 N and 6.5-129.3 N, respectively. PDnorm and ADnorm ranged from 0.37–1.20 /m and 0.36-2.55 /m, respectively. There was a clear trend for ADnorm to increase as the level of physical impairment became more severe (S class decreased) (S10-S8: 0.55 ± 0.10 /m → S7-S5: 0.70 ± 0.19 /m → S4-S1: 1.10 ± 0.61