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A Comparison of Two and Three Dimensional Motion Capture Methodologies in the Analysis of Underwater Fly Kicking Kinematics

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Abstract : Underwater fly kick is an essential skill in swimming, which can have a considerable impact upon overall race performance in competition, especially in sprint events. Reduced wave drags acting upon the body under the surface means that the underwater fly kick will potentially be the fastest the swimmer is travelling throughout the race. It is therefore critical to understand fly kicking techniques and determining biomechanical factors involved in the performance. Most previous studies assessing fly kick kinematics have focused on two-dimensional analysis; therefore, the three-dimensional elements of the underwater fly kick techniques are not well understood. Those studies that have investigated fly kicking techniques using three-dimensional methodologies have not reported full three-dimensional kinematics for the techniques observed, choosing to focus on one or two joints. There has not been a direct comparison completed on the results obtained using two-dimensional and three-dimensional analysis, and how these different approaches might affect the interpretation of subsequent results. The aim of this research is to quantify the differences in kinematics observed in underwater fly kicks obtained from both two and three-dimensional analyses of the same test conditions. In order to achieve this, a six-camera underwater Qualisys system was used to develop an experimental methodology suitable for assessing the kinematics of swimmer's starts and turns. The cameras, capturing at a frequency of 100Hz, were arranged along the side of the pool spaced equally up to 20m creating a capture volume of 7m x 2m x 1.5m. Within the measurement volume, error levels were estimated at 0.8%. Prior to pool trials, participants completed a landside calibration in order to define joint center locations, as certain markers became occluded once the swimmer assumed the underwater fly kick position in the pool. Thirty-four reflective markers were placed on key anatomical landmarks, 9 of which were then removed for the pool-based trials. The fly-kick swimming conditions included in the analysis are as follows: maximum effort prone, 100m pace prone, 200m pace prone, 400m pace prone, and maximum pace supine. All trials were completed from a push start to 15m to ensure consistent kick cycles were captured. Both two-dimensional and three-dimensional kinematics are calculated from joint locations, and the results are compared. Key variables reported include kick frequency and kick amplitude, as well as full angular kinematics of the lower body. Key differences in these variables obtained from two-dimensional and three-dimensional analysis are identified. Internal rotation (up to 15º) and external rotation (up to -28º) were observed using three-dimensional methods. Abduction (5º) and adduction (15º) were also reported. These motions are not observed in the two-dimensional analysis. Results also give an indication of different techniques adopted by swimmers at various paces and orientations. The results of this research provide evidence of the strengths of both two dimensional and three dimensional motion capture methods in underwater fly kick, highlighting limitations which could affect the interpretation of results from both methods.

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