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INVERSE DYNAMICS APPROACH TO THE BIOMECHANICS OF SWIMMERS USING MULTIBODY DYNAMICS METHODOLOGIES

Jorge Ambrósio[1], Francisca Simões[1], Mariana Sequeira[1], Carlos Quental[1], João Paulo Vilas-Boas[2]
[1]IDMEC - Instituto Superior Técnico, University of Lisbon, Portugal
[2]Sports Faculty, University of Porto, Portugal
jorge.ambrosio@tecnico.ulisboa.pt, francisca.simoes@tecnico.ulisboa.pt,
marianafsequeira@tecnico.ulisboa.pt, carlos.quental@tecnico.ulisboa.pt, jpvb@fade.up.pt

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Summary: Human motion is one of the objects of study in biomechanics, which involves complex interactions between the neuromuscular and skeletal systems. Understanding these interactions is necessary not only for medical applications but also for sports sciences or for planning physical conditioning activities. Fundamental quantities of interest in human motion research are the intersegmental forces and moments acting at the joints, which represent the net loads that act at each biomechanical joint, and muscle forces. Computational biomechanical models based on multibody dynamics are powerful tools that enable the evaluation of these quantities in the human body, whose in vivo or in vitro measurement is, when possible, extremely difficult. In the context of human swimming, current biomechanical models are mostly based on simplified models of specific parts of the human body. Due to limitations on motion acquisition, especially in the air-water interface, they are kept simple and are hardly able to simulate the broad range of motion of many of the anatomical segments relevant to swimming. Another fundamental data for the evaluation of internal forces are the external forces acting on the human body during swimming, herein referred to as hydrodynamic forces. Unlike terrestrial motion where these external forces are easily measured using force platforms, the determination of the external forces in water is very difficult. This work provides a methodology that allows overcoming the difficulty in obtaining the external forces acting on the swimmer, by estimating them using the Swimming Human Model computational tool, SWUM. These forces distributed on the swimmer biomechanical model anatomical segments are used, together with the model kinematics whose movement is acquired experimentally in the swimming pool, to obtain the internal forces in the model. The methodology presented and discussed in this work is applied to a swimmer using a freestyle technique, crawl. The results obtained allow for the evaluation of the internal forces in the human body biomechanical model which are of particular interest to understand what is the contribution of each anatomical segment for the thrust of the swimmer and what are the forces required to develop such movement. In the process, the estimation of the 'joint reaction' forces allows to have an estimation of the health risks to develop this swimming technique.