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Musculoskeletal modelling in sports - evaluation of different software tools with focus on swimming

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Abstract

Previous swim start measurements at *Chalmers University of Technology* involved electromyography (EMG) in order to get an overall picture of the muscle activation pattern during the swim start. In order to fully evaluate sports performance trainers may facilitate additional tools, like videography and force plates, to be able to underpin the feedback given to the athletes. However, the output of the different tools are often complicated and lengthy to handle. Therefore it would be valuable to find an easily applicable tool to visualize biomechanical data. Feedback to athletes based on scientifically measured variables would then ideally be more efficient and effective. This paper evaluates three different software tools regarding musculoskeletal modelling and simulation with quick, meaningful and unambiguous data processing and presentation: *OpenSim*, *BoB* and *AnyBody*. The software package *SWUM* was also analyzed as it is currently the only tool that can model forces and buoyancy during swimming. It has been found that *OpenSim* is a beneficial tool for academic projects as it is freely available and provides a big pool of users and papers available to support the user with additional knowledge. *BoB* is the most straight-forward tool being appropriate for biomechanical teaching and applications where a fast analysis is required. *AnyBody* has the most sophisticated model which can be adjusted to the users demands in great detail and is favorable for investigations with focus on the interaction between the body and the environment or a detailed medical analysis. Great potential lies in the further development and usage of *SWUM* as its basic interface with valuable outputs and simulations as well as the possibility of connecting to *AnyBody* might allow for advancements in swim training.

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1. Introduction

In elite swim races fractions of a second decide on success or defeat. Therefore the analysis of human motion has always been of interest in sports so that swimmers can improve every movement of the race. Musculoskeletal models and simulations driven by previously recorded motion data are nowadays a common method to investigate motion patterns in detail as it has been understood that muscles and joints - the initial units driving the athlete - should be investigated further [1–3]. However, the focus of modelling tools in sports including bones and muscles is only seldomly placed on swimming as numerical simulation in the water environment is demanding [4,5]. Projects like the

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complex CFD crawl model of Keys et al. mainly deal with the flow field around the swimmer and its motion, but do not comprise musculoskeletal modelling [6]. Another study developed a realistic musculoskeletal swimming model driven by neural network activations but do not allow for easy customization of the model [7]. Moreover only some papers discuss the actual usability of these tools for unexperienced persons like trainers and physiotherapists [8].

The work presented in this paper is supposed to be an evaluation of tools regarding musculoskeletal modelling and simulation with application in swimming. It is intended to investigate whether the properties of the different software packages permit individual adjustments regarding posture and environment as well as the data import from various motion analysis modalities used in competitive swim training. This includes videography and force plate data as well as EMG data from a previously conducted study involving the nowadays most common start dive techniques of competitive swimming events [9]. Additionally it will be assessed whether a steep learning curve for new users is achievable and a supporting analysis within a limited time frame is feasible. It is assumed that the application of a visual, scientific tool in swim training can improve training session by making it more versatile and by explaining biomechanical concepts in not only numbers and graphs but also images and videos [10,11].

Besides the usage of such tool may aid in a better understanding of potentially injury causing movements and thereby aid in injury prevention [8,12,13]. As swimmers are predisposed to musculoskeletal injuries like swimmer's shoulder, overuse and fatigue, a visual presentation of their muscle usage is assumed to clarify that a correct, versatile training and a sufficient amount of rest is just as important as the training itself [14,15].

2. Methods

Many tools can be found for a biomechanical analysis of motion capture data in sports. This paper focuses on the applications which encompass a musculoskeletal representation of the human body allowing the evaluation of muscle activations during the observed motion. Therefore three differing tools have been selected. The first one is the plain *Matlab*-based tool *BoB*, the second is the more advanced, widely used freeware *OpenSim* and the third is the purchasable software *AnyBody* which is one of the most detailed and multifunctional tools on the market. In addition to these packages the software *SWUM* is implemented as it provides the essential calculation of fluid forces for modelling in swimming.

All tools have been applied from the first step of converting and inputting motion capture data via the detailed scaling of the model to various analysis procedures. If possible previously captured start dive data from developmental level swimmers was used (*Qualisys* motion capture). In case the number or naming of the facilitated markers did not match the requirements of the software, freely available trial data has been utilized. Additionally forums and direct conversations with the producers have been consulted to gain an all-encompassing insight into the scope of each tool.

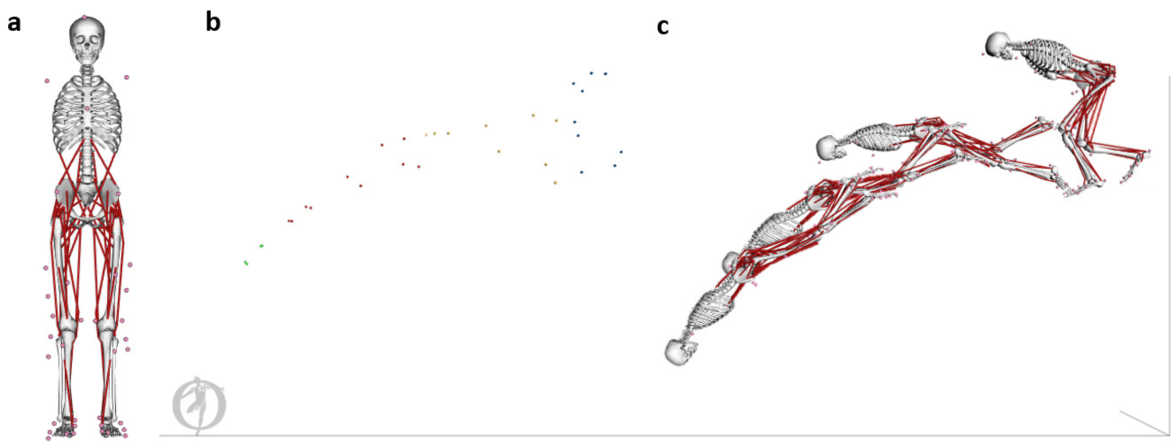

Fig. 1. (a) Lower extremity model of *OpenSim*; (b) *Qualisys* motion capture data from the start jump in swimming imported into *OpenSim*; (c) *OpenSim* model follows the markers after performing the inverse kinematics analysis.