Guest editorial

Special issue: Progress in shoulder biomechanics

This special issue presents papers that arose from the bi-annual International Shoulder Group (ISG) meeting in Minneapolis in July 2010. The ISG is a collaboration of mostly biomechanically oriented research groups, whose main interest is in the shoulder. It was founded in 1989 and has been a Technical Group of the International Society of Biomechanics since 1999. The ISG aims to enhance shoulder research by creating a platform for discussion as well as for the exchange of information, software and data. The bi-annual meetings are one-session meetings intended to stimulate contacts between participants new in the field and more experienced members, and to stimulate translational research, i.e., research that seeks to bridge the gap between basic science and clinical applications.

The ISG 2010 meeting brought together investigators with a broad diversity of research interests, ranging from sports to clinical applications and applied research to the development of research tools. Over 40 presentations were given, five of which have been elaborated into a full paper for this special issue of Human Movement Science.

One of the major difficulties in upper extremity research is the measurement of scapular motion, while this motion is essential for healthy shoulder function. Over the last decade, the awareness of the importance of the scapular contribution has clearly increased (Kibler & Sciascia, 2010), but the precise measurement of its motion is still complex due to soft-tissue artifact and the explicit three-dimensional kinematics (Veeger, van der Helm, Chadwick, & Magermans, 2003). Although ISG has been instrumental in streamlining analysis methods and descriptions (Kontaxis, Cutti, Johnson, & Veeger, 2009; Wu et al., 2005), uncertainty still exists as to what extent recently published measurement methods can be applied for the description of scapular motion. Where the ISG has adopted the scapula locator procedure (Johnson & Barnett, 1996) as the ‘silver standard’ for the measurement of scapular motion, this method is not suitable for motion recordings in scapula (re)training studies due to the quasi-static character of the measurement and the confounding feedback effect of the method. Warner et al. tried to solve part of this problem by using an acromion marker cluster to describe the arm-lowering phase in an abduction motion. While the method is not perfect, the measurement system in question provided a reasonable description of scapular kinematics, likely suitable for the evaluation of scapula retraining effects.

To date there is no general consensus as to what constitutes deviant shoulder motion in quantitative terms. Of course, extremes can be identified, but the influence of small differences in scapular rotations, especially spinal tilt and pro-retraction, on potential upper extremity trauma is not clear, which is at least partially due to the difficulties related to the accurate measurement of shoulder motion. Raina et al. attempted to qualify the effect of wheelchair propulsion on shoulder motion to identify the risk of impingement and used an acromion sensor to do so. A higher work load led to a change in motion pattern with more downward rotation, tilt and protraction, which is assumed to increase the risk for impingement (Ludewig & Cook, 2000). Borstad and Szucs performed a pre-post study on the effect of surgical intervention on shoulder kinematics in patients with breast cancer. In particular,
Scapula protraction was increased, which appeared to be the result of soft tissue alterations due to surgery and might be responsible for the significantly lower shoulder function.

Where the above-mentioned papers try to quantify shoulder kinematics to use this information for the identifications of risk factors or decreased shoulder function, de Vries et al. report on the development of a method to quantify shoulder load with the use of a musculoskeletal model. They describe a method to obtain input for a musculoskeletal model based on ambulatory collected kinematics of the arm and trunk, in combination with EMG input. After training of a neural network to produce the required input, shoulder loads were predicted with sufficient accuracy to allow for the study of shoulder load profiles under daily conditions. Musculoskeletal models of the shoulder are, however, not yet perfect. Nikooyan et al. intended to improve an existing shoulder model by extending the model input with recorded EMG's of selected shoulder muscles. The inclusion of EMGs showed to improve the predicted joint reaction forces (when compared to direct measurements with an instrumented endoprosthesis), especially above 90° elevation.

Impingement is probably one of the most common shoulder inflictions, and can lead to severe impairments and pain. Impingement can lead to serious rotator cuff damage, which in turn can lead to complete joint destruction and the need for replacement of the glenohumeral joint. How to intervene in the downward spiral of impingement and joint damage is probably one of the most challenging research topics, for which more work on the understanding of the pathogenesis, as well as on successful interventions is warranted. Chopp and Dickerson examined the effect of fatigue on migration of the humeral head using a simulation approach and concluded that the effect of fatigue on humeral head migration should not be underestimated and taken into account when looking at arm work in industry.

When, for instance due to impingement, tears in the rotator cuff muscles have developed, this will affect the shoulder movement potential, although some of the function loss can, at least on a mechanical basis, be compensated by other shoulder muscles. How, and to what extent, this takes place is important in order to understand the differences in functional outcome between patients with apparently identical rotator cuff trauma. De Witte et al. report on the development of a systematic analysis method to analyze individual muscle contributions based on the concept of an “Activation Ratio” that expresses the relative co-activation of a muscle in non-agonistic force directions in a static force task. The method allowed them to distinguish patients from controls and it was concluded that the method would be suitable for a more in-depth study of asymptomatic versus symptomatic rotator cuff tears.

The last contribution in this special issue is a study by Frère et al. on the recruitment of shoulder muscles during the backward giant swing. The authors used a wavelet-EMG analysis to identify patterns of muscle co-activation. Two main muscle groups could be discerned: one group responsible for stabilization and strength and a second group for the rotation acceleration in the last phase of the swing before release.

We hope that this selection of papers will aid readers in understanding the complex function of the shoulder and the close relationship between upper extremity structure and function, as well as the influence of structure damage on function. Of course, with the publication of this issue, a complete understanding of shoulder biomechanics has not yet been obtained. We are certain, however, that another step in the right direction has been made and that papers to be presented at the 2012 ISG meeting in Aberystwyth will reflect that development.

To conclude this editorial, we would like to thank our reviewers whose expert comments have certainly contributed to the quality of the present selection of papers. Needless to say, the quality of the present selection of papers is achieved thanks to their much-appreciated efforts. Therefore, the guest editors would like to sincerely thank the following individuals who served as reviewers for the papers in the present special issue:

**List of reviewers**

John Borstad, Ohio State University, Columbus (USA)
Edward Chadwick, Aberystwyth University, Aberystwyth (UK)
Andrea Cutti, Centro Protesi INAIL (IT)
Andrew Karduna, University of Oregon (USA)
References


Editors

Dirkjan (H.E.J.) Veeger
VU University/Delft University of Technology, The Netherlands
E-mail address: h.e.j.veeger@vu.nl

Andrea G. Cutti
Centro Protesi INAIL, Italy
E-mail address: ag.cutti@inail.it