TEACHING INTRODUCTORY AND ADVANCED BIOMECHANICS IN GERMANY AND THE UNITED STATES OF AMERICA

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This paper will review differences and similarities of teaching biomechanics in Germany and the United States. Data of typical biomechanics course offerings in exercise science/sports science programs for both countries will be presented. Furthermore, the structure of course offerings will be discussed with respect to lecture/lab and active learning opportunities.

KEYWORDS: Teaching, Education, Active Learning,

The discipline of biomechanics is an integral part of undergraduate and graduate degrees in exercise science and kinesiology across the world. This abstract will focus on biomechanics courses taught in exercise science/kinesiology programs the United States of America and Germany. In the United States undergraduate degrees in exercise science/kinesiology are often used to qualify for graduate programs and PhD programs in various health science related fields of study. Conversely, German undergraduate degrees are usually chosen as 'final destination' with a narrower focus on sports related topics. In the United States exercise science/kinesiology degrees are often the starting point for careers in athletics, health sciences, physical therapy, physician assistants, medical doctors, personal training, physical education, and academia (AKA 2016). German undergraduate degrees qualify for physical education, personal training, coaching, sport therapy and rehabilitation, sport management, sport engineering, and academia (DVS 2016).

Biomechanical knowledge is necessary to understand and study human movements. According to the National Association for Sport and Physical Education (USA), learner outcomes of undergraduate biomechanics education should include skills to:

- observe and describe a movement technique;
- identify mechanical factors contributing to performance; determine suitability of a movement technique for a given task;
- optimize movement techniques;
- identify and prioritize performance limiting factors.
  (National Association for Sport and Physical Education 2003).

Fittingly, faculty identified in a North American Survey (N=279, Garceau et al. 2012) the following subjects among the most important: kinematics including linear and angular kinematics (88.5%), kinetics, including linear and angular kinetics (69.8%%), Newtonian Laws (21.9%), movement analysis (16.7%), tissue mechanics/properties (16.7%), and clinical/real world applications (12.5%) (Garceau et al. 2012). Comparable studies on German biomechanics courses do not exist. The data on German biomechanics courses presented in this paper is based off coursework requirements for degrees in exercise science/sport science at German universities. Therefore, all modules, and study guides of German exercise science/sport science programs were reviewed. The data-base includes all course offerings within the last academic year in programs leading to a bachelor/master of arts or bachelor/master of science (N=49). Our data-base, class syllabi and standard textbooks used suggest a similar priority list for German biomechanics classes as reported for North America.

Another recommendation of the National Association for Sport and Physical Education (USA) is that students in exercise science/kinesiology should – as a minimum standard - complete one biomechanics class with a lab component attached to it (National Association for Sport and Physical Education 2003). According to the North American Survey 83.4% of classes taught focusing on biomechanics content were specifically labeled with 'biomechanics' in the title (Garceau et al. 2012). The term 'biomechanics' is used less frequently in Germany and biomechanics content is often taught in the context of movement science or movement studies as well a trainings sciences (Table 1).

Table 1: Course topics listed for classes with biomechanics content. Data for the USA was derived from Garceau et al. 2012.

	Germany	USA
Course topic (DE: N=49; USA: N=127)	%	
Kinesiology/applied anatomy/exercise mechanics	23.1	10.6
Biomechanics (i.e. Lectures or Seminars with 'Biomechanics' in the title)	64.1	83.4
Movement Analysis (i.e. Mechanical Analysis of Human Movement, Measurement Techniques and Performance Diagnostics)	12.8	6

A common approach to offer biomechanics lectures in the USA is a three-credit lecture and 61% of all lectures are offered with a lab component (Garceau et al. 2012). That usually translates to three one-hour lectures and a one- or two-hour lab session per week. German programs usually offer stand-alone lectures (one two-hour lecture/week) that are sometimes (17%) coupled with a study session. Additional lab based classes were listed by 39% of the programs and typically offered as two-hour session once a week. Additionally, 47% of the German programs offered 'seminars' that are usually very problem centered, more applied than lectures, and often relate to ongoing research of the biomechanics faculty. Biomechanics course offerings combined with weekly lab activities or problem centered seminars foster active learning, which is associated with higher student success rates (Freeman et al. 2014).

In conclusion, the knowledge content covered in bachelor and master programs is similar in both countries. However, the teaching philosophy related to lab activities/active learning as an integral part of biomechanical lectures differs.

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NEW RESEARCH APPROACHES ARE UNRAVELLING THE MYSTERY OF PROPULSIVE MECHANISMS IN SWIMMING

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Various explanations regarding how swimmers generate propulsion have been proffered during the last half century. Investigations have been limited by the current technical 'state of the art'. The main limitations have related to the difficulty of directly measuring propulsive and resistive forces and in observing the behaviour of the fluid. The purpose of this presentation is to provide an historical account of how developing methods of analysis are enabling us to unravel the mystery of propulsion in swimming.

Many of the early analyses of propulsion focused on the propulsion produced by the hands. This focus was based on the assumption that the hands were the dominant source of propulsion following various estimates of the contribution of the hand relative to the kick through indirect measurement techniques. Based on the observation that elite swimmers used lateral motions during swimming there was a belief that good swimmers were 'scullers' and that much of the propulsion was generated by lift rather than drag forces as the water flowed across the hand with small angles of attack. The hand was analogised to an aeroplane wing generating lift by the Bernoulii effect.

To assess the veracity of the claim that lift from the hand motions was possibly more important than drag, and to quantify the relative contributions of lift and drag throughout the stroke cycle, several authors conducted controlled experiments in which the hand was set at known orientations of pitch and sweepback angle to the flow. The idea was that once the lift and drag coefficients were known these could be applied to determine the forces produced in actual swimming through quantifying the orientation of the hand and the rate of flow using video-based three dimensional analysis techniques. This indirect approach assumed that the flow was regular, that is. 'quasi static' and that unsteady effects due to irregular and non-laminar the flow would not greatly affect the interpretability of the findings. However, two main factors conspired to minimise the contribution of this approach to knowledge of force production in swimming. The first was that determining the orientation of the hand in actual swimming using video-based three dimensional analysis techniques is very problematic and labour intensive. Second, there was evidence that the actual forces were underestimated. Consequently, there was increasing recognition of other influences such as 'added mass effects' due to accelerations of the limbs relative to the water, and forces associated with the production and shedding of vortices, could not be ignored. Nevertheless, these research approaches had been successful in dispelling the long-standing misconception that skilled swimmers generated force mostly from lift using 'sculling motions'. Attention now turned to considering the role of those unsteady effects.

Development of new technologies in that last 15 years has helped to unravel the mystery of the mechanisms of propulsion in swimming. In particular, researchers at the University of Tsukuba have advocated a 'multi-pronged' approach to yield improved understaning of the mechanisms of propulsion. These include the use of direct force measurement using pressure transducers on the hands or on hand models, the developing software simulation technology of computational fluid dynamics (CFD) and quantification of actual fluid flow via particle image velocimetry (PIV). The researchers have combined these methods with direct force meansurement of the forces generated by limb models driven by programmed robots. The various data sets are input to the to human swimming simulation software (SWUM).

The presentation will conclude with an overview of what we know as a consequence of the research over the last 50 years and some of the questions still to be addressed.

INTEGRATIVE APPROACHES FOR SUCCESSFUL REHABILITATION

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Currently it is common that sport biomechanists and orthopedic surgeons work together for sports injury prevention and rehabilitation training in Korea. Functional training is the latest issue in not sports injury prevention but rehabilitation at the moment. It works on the premise that the body is designed to work by performing patterns of movement which engages muscles in natural way rather than in one plane of movement. Understanding how each of the body's joints or systems works independently is essential to see whether that section has the capacity to function as part of the whole. A biomechanical screen will provide this information and is used as a precursor to functional screening and training. Once each joint or system has the capacity to function correctly, functional training using combinations of joints and systems, then becomes more likely and the movements are pure not compensatory. Dr. Junggi Hong is the most active scholar and practitioner in the performance training and sports medicine for athletes in Korea. He contributes athletic rehabilitation and injury prevention field in Korea through co-work with many athletic trainers in various professional sports teams and physicians in sports medical centers in Korea.

Allowing a patient to return to sport and unrestricted physical activity after ACL injury and reconstruction is one of the most challenging and difficult decisions an orthopaedic surgeon has to make. Indeed, many factors have to be taken into account before it can be considered safe for a patients to load a reconstructed knee. Dr. Jin Koo Kim is the best physician for athlete's ACL reconstruction and researcher in sports medicine, especially at evaluating return to sport. As a director of ports medical center at Kunkuk general hospital, he works with many trainers who graduated sports science major from the athletes' ACL reconstruction to successful return to sports through evidence based rehabilitation training. While currently they are using one-legged hop test, muscle co-contraction test, Carioca test, and isokinetic muscle strength test to evaluate rehabilitation progress and to make decision the return to sports, they also are doing many research for application of information and communication technology, such as various sensor technology and virtual reality system to athletic rehabilitation training and evaluation the return to sport.