INTRODUCTION

The biomechanics community lost one of its founding fathers on August 1, 2002. After a long battle with cancer, James G. (Jim) Hay died at his home in New Zealand. He was only 65 years old. Jim helped form the American Society of Biomechanics and hosted the very first ASB meeting in the Fall of 1977 at the University of Iowa. While at Iowa, Jim trained some of the finest scholars in biomechanics today, including Walter Herzog and Kit Vaughan. Jim was a phenomenal teacher and researcher of sports biomechanics, particularly track and field and swimming. He also developed a method to compute total body angular momentum and published two highly successful textbooks that will continue to be updated after his death. This symposium will highlight some of Jim Hay’s greatest contributions to biomechanics.

HAY’S DETERMINISTIC MODELS AND THEIR USE IN SPORT BIOMECHANICS

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*The Biomechanics of Sports Techniques* (first published in 1973) contains chapters on different sports. In each chapter, Jim presented what he would eventually call “deterministic models” (DMs) or block diagrams that outlined the relationships between the result of a given motor skill (e.g., time, height, or distance) and various factors that determine that result (e.g., step length, forces exerted). The models have been used for both quantitative and qualitative purposes. One of the first quantitative studies used a DM to examine the critical factors in the performance of a vertical jump (1976). In the 1980s Jim and his students used DMs to quantify the critical factors in the long jump, and resulted in improvement in performance of elite U.S. long jumpers. With the debut of Jim’s second book *The Anatomical and Mechanical Bases of Human Motion* (1982), the DM became an integral part of improving human performance qualitatively (e.g., “by eye”). This method of Qualitative Analysis has revolutionized the way coaches and teachers evaluate and eliminate faults in performance. DMs (“Hay-o-grams”) may be Jim’s greatest contribution to biomechanics.

THE EARLY DAYS: COMPUTATION OF ANGULAR MOMENTUM AT IOWA

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In the 1970’s there was an active Biomechanics “think tank” centered at the Fieldhouse. The interests of the group were diverse to the extent of working on, and even concocting, novel track and field techniques: the somersault long jump (Tom Ecker) and the dive high jump (Jim). Questions posed to Jim by his good friend George Nissen, of Nissen Gymnastics, often resulted in studies, eg: toppling of gymnastics vaulting horses, rotation of a gymnast who had missed a vault, analysis of gymnastics giant circles, and gymnastics tumbling. Many reports describing and explaining angular motion were written for Nissen before the methods used were
presented by Jim at ACSM in 1975. Determining an appropriate set of segment parameters to use in calculations and validating the computation process kept the lab on task for a further two years. A comparison of three methods of calculating angular momentum was presented in Jyvaskyla in 1975, and a paper on the toppling dive was published in early 1977. The culmination of Jim’s work on angular motion was the *Journal of Biomechanics* paper “A computational technique to determine the angular momentum of a human body”, published in 1977.

**HAY’S RESEARCH ON THE BIOMECHANICS OF THE LONG JUMP**

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Jim’s research on long jumping covered three main topics: description of the mechanics of the jump, correlational analysis, and analysis of the strategies used to achieve accuracy in the placement of the takeoff foot. This work was based on two-dimensional motion analysis of elite long jumpers in competitions. He found that long jumpers, on the average, start making adjustments for accurate placement of the takeoff foot about five steps before takeoff. His work also suggested the features of the optimum technique. Long jumpers should have a large horizontal velocity two steps before takeoff. In the next step, they should lower the center of mass (CM), and plant the foot slightly further ahead than in normal running. This preparation causes some loss of horizontal velocity, but it is overall beneficial. In the last step, they should maintain the CM height, and plant the takeoff foot clearly ahead of the CM. The low CM height and the forward position of the takeoff foot will produce a larger loss of horizontal velocity during the takeoff, but the associated increase in vertical velocity will more than compensate for it.

**METHODOLOGICAL DEVELOPMENTS FOR BIOMECHANICAL ANALYSIS OF SWIMMING TECHNIQUES**

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Biomechanical analyses of swimming techniques are especially difficult to conduct, due to the medium in which the techniques are performed. Dr. Hay and his students at Iowa devoted their energies to this challenging task in order to improve the understanding of the biomechanics of swimming. A series of innovative research methods were developed for kinematic analysis: the inverted periscope, the half periscope and the panning periscope. A method was also developed to record the details of the water flow. Dr. Hay hoped to deduce the forces acting on the swimmer from the observed motions of the water around the swimmer’s body. A doctoral student adopted a totally different approach, pressure analysis, for the determination of the propulsive hand forces. These attempts at kinetic analysis were made in response to a previous doctoral study in which the most widely recognized method for the determination of propulsive lift and drag, devised by Schleihauf, was found to be invalid for unsteady flow conditions.