KINEMATIC ANALYSIS OF SPORTS MOVEMENTS: GOLF SWING PLANE ANALYSIS

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Abstract

INTRODUCTION: Kinematics is an area of biomechanics dealing with measurement and description of the human body motion. Quantitative measurement of the motion of interest and subsequent analysis based on the computed kinematic quantities allow investigators an in-depth understanding of the motion itself and the common motion patterns. The human body is a mechanical system with a large number of degrees of freedom and isolating a set of key performance characteristics/components is of crucial importance for effective performance enhancement in complex 3-dimensional (3-D) body motions such as the golf swing. Golf is one of the most popular sports in the modern world with 35 million participants worldwide (Geisler, 2001; Theriault & Lachance, 1998). The sole objective in a golf competition is to minimize the total number of shots taken to finish an 18-hole course using a variety of clubs and shots. The two most important elements of the performance in golf are accuracy (direction and distance) and consistency and one must develop a consistent fundamental swing pattern to secure these qualities. The direction of a shot and the ball carry distance are essentially determined by the clubhead velocity, clubface orientation, impact location on the clubface, coefficient of restitution, and the effective mass involved in the impact. The ‘swing plane’, which affects the impact conditions directly, is one of the most frequently used terms in golf coaching lately and is also one of the most controversial and misleading concepts. Since Hogan and Wind (1957) used this term in their book titled “Ben Hogan’s five lessons: the modern fundamentals of golf”, different swing theories have emerged in the popular literature (e.g. Haney & Huggan, 1999; Hardy & Andrisani, 2005). None of these, however, has truly grasped the essence of the swing plane due to the lack of understanding of the complex nature of the actual 3-D swing motion. Moreover, for last four decades, the majority of biomechanical studies on swing mechanics have been conducted based on the planar double-pendulum model (e.g. Budney & Bellow, 1979; Milburn, 1982; Milne & Davis, 1992; Pickering & Vickers, 1999; Sanders & Owens, 1992), originally proposed by Cochran and Stobbs (1968), or the triple-pendulum model (Sprigings & Mackenzie, 2002; Sprigings & Neal, 2000), a variation of the double-pendulum model. Although Vaughan (1981) and Neal and Wilson (1985) pointed out that the swing plane was not planar, it is only recently that scientists have critically investigated the swing plane (Coleman & Anderson, 2007; Coleman & Rankin, 2005; Nesbit, 2005; Shin, Casebolt, Lambert, Kim, & Kwon, 2008). The purpose of this paper is to provide a comprehensive review of both the scientific and the popular golf literature on golf swing mechanics in regards to the concept of swing plane.

Keywords

golf swing mechanics; on-plane swing; one-plane swing; double-pendulum

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3D kinematic and kinetic data were recorded at 240Hz with a high-speed motion capture system and a forceplate imbedded in the floor. Biomechanical variables included peak stance torque and torque at the top of backswing (moment about the vertical axis with both feet on the forceplate), peak clubhead speed, peak and average weight shift velocities (center-of-pressure in the medio-lateral direction) as well as peak X-factor and X-factor at impact. The X-factor was calculated as the angle between the line through the right and left anterior superior iliac spines and the line through the right a