Coordination of segments in the vertical jump

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ABSTRACT
HUDSON, J. L. Coordination of segments in the vertical jump. Med. Sci. Sports Exerc., Vol. 18, No. 2, pp. 242-251, 1986. Three general patterns of segmental coordination (i.e., sequential [SEQ], simultaneous [SIM], and modified simultaneous [MSIM]) have been hypothesized for jumping. The purposes of this study were to describe the pattern of segmental coordination used in vertical jumping and to determine if skilled jumpers displayed distinguishing patterns of coordination. Maximum vertical jumps were performed in the counter movement (CMJ) and static jump (SJ) conditions by a heterogeneous group of 20 lean, adult subjects (AS). Smoothed, digitized film records provided the data for four segments: head-arms-trunk, trunk, thighs, and shanks. For each segment the phase of positive contributions was considered to begin with initiation of extension and end with maximum angular velocity. Bisegmental and multisegmental variables were defined to assess the extent of simultaneity. Skill was determined by the effective integration of the legs (ratio of peak upward velocity of CMJ and SJ) and by the use of stored elastic energy. Although 13 AS had MSIM patterns, the amount of flexion was small (<1°) so these AS were reclassified. With multisegmental analyses the number of AS with SIM patterns ranged from 13 to 17; about half the time was SIM. Using bisegmental analyses all 20 AS had SIM patterns; about three-fourths of the time was SIM. Skilled AS initiated extension and reached maximum velocity of the segments in proximal to distal order and with very small delays between adjacent segments.

BIOMECHANICS, STORED ELASTIC ENERGY, SKILL, TECHNIQUE, TIMING

Coordination is generally believed to be one of the primary ingredients in proficient performance. Yet, the research and teaching literature in biomechanics is sparse and imprecise on this topic. The predominant use of the word coordination is in the context of the timing of segmental movement. According to Northrip et al. (10), coordination is the creation of an optimal result through the proper sequential production of individualized forces. Hence, the timing and sequencing of segmental movement appear to be the bases of coordination.

By extending the discussion of Kreighbaum and Barthels (7) with respect to segmental movement, coordination can be depicted on a continuum (Fig. 1). The extremes are represented by patterns in which the segments move sequentially or simultaneously. Tasks in which the object is light and/or the distal end of the linkage is open (e.g., baseball throwing) are presumed to be sequentially timed. Tasks in which the object is heavy and/or the distal end of the linkage is closed (e.g., the squat in weight lifting) are expected to be timed simultaneously. Intermediate tasks (e.g., shot putting) would be predicted to have intermediate timing. The position of a task on the continuum may be influenced by the importance of velocity and accuracy: when velocity is important, the pattern is expected to be more sequential; when accuracy is important, the pattern is expected to be more simultaneous.

Three general patterns of segmental coordination (Fig. 2) have been hypothesized for jumping:
1) A sequential pattern has been advocated by Lutgens and Wells (8). The classical sequential pattern, in which each distal segment initiates movement at the time of peak velocity of the adjacent proximal segment, was proposed by Morehouse and Cooper (9). Based on the coordination continuum of Figure 1, a sequential pattern could be supported for vertical jumping because take-off velocity determines the height attained.
2) A simultaneous pattern has been postulated for jumping due to the large forces required by the task (7). In this pattern all segments initiate extension at the same time. A simultaneous pattern is theoretically appealing because the object is heavy, the chain is closed, and accuracy is desirable.
3) A modified simultaneous pattern has been suggested by Hopper (3). In this pattern simultaneous extension is attempted, but the acceleration of trunk extension is expected to force the knee and ankle into additional flexion before the movement becomes simultaneous.

As a means of examining the theoretical basis of coordination, there were two purposes of this study: to describe the pattern of segmental coordination which is used in vertical jumping and to determine if skilled jumpers display distinguishing patterns of coordination.

METHODS

Subjects. Twenty lean, young adults gave informed consent to participate in this study. All subjects were