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Effect of stride length on overarm throwing delivery: A linear momentum response ☆,☆☆

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ABSTRACT

Changing stride length during overhand throwing delivery is thought to alter total body and throwing arm linear momentums, thereby altering the proportion of throwing arm momentum relative to the total body. Using a randomized cross-over design, nineteen pitchers (15 collegiate and 4 high school) were assigned to pitch two simulated 80-pitch games at ±25% of their desired stride length. An 8-camera motion capture system (240 Hz) integrated with two force plates (960 Hz) and radar gun tracked each throw. Segmental linear momentums in each plane of motion were summed yielding throwing arm and total body momentums, from which compensation ratio's (relative contribution between the two) were derived. Pairwise comparisons at hallmark events and phases identified significantly different linear momentum profiles, in particular, anteriorly directed total body, throwing arm, and momentum compensation ratios ($P \leqslant .05$) as a result of manipulating stride length. Pitchers with shorter strides generated lower forward (anterior) momentum before stride foot contact, whereas greater upward and lateral momentum (toward third base) were evident during the acceleration phase. The evidence suggests insufficient total body momentum in the intended throwing direction may potentially influence performance

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(velocity and accuracy) and perhaps precipitate throwing arm injuries.

1. Introduction

Early within the pitching delivery, total body linear momentum is first generated by the drive leg (trailing or dominant) and is then arrested by the stride leg (leading or non-dominant) at stride foot contact (Seroyer et al., 2010; Stodden, Langendorfer, Fleisig, & Andrews, 2006). Thereafter, linear momentum transitions into rotation between the pelvis and trunk, through to the throwing arm, and culminates at the hand (Seroyer et al., 2010; Stodden et al., 2006). A recent study that examined the chain of body segment momentum transfers in the baseball pitching delivery suggest the greatest linear momentum progresses forward in the intended throwing direction (toward home plate), with the trunk contributing the greatest proportion of all linear and angular momentum transfers (Lin, Su, Nakamura, & Chao, 2003). In contrast, momentum approached zero near ball release with the contralateral non-throwing arm and leg, which is thought to augment forward trunk flexion momentum (Lin et al., 2003). Reducing forward total body momentum late in the pitching cycle may be attributable to improved proximal stability to augment sagittal plane trunk and throwing arm angular momentums (Lin et al., 2003). Evidence suggests that the ability to regulate forward momentum is related to throwing arm performance, with the lower body greatly influencing sequential and coordinated momentum transfers up the kinetic chain (Lin et al., 2003; Seroyer et al., 2010; Stodden et al., 2006). Pelvic and trunk linear momentums were shown to contribute the greatest to ball velocity, rather than constituent momentums from the throwing arm segments themselves (Bahamonde, 2000; Lin et al., 2003).

Yet, it remains unknown whether modifying stride length (the horizontal distance between the drive and stride foot calcanei) can alter intrinsic lower extremity mechanics and inter-segmental momentum transfers to the pelvis and torso, potentially to the detriment of synchronous proximal–distal trunk-throwing arm mechanics.(Lin et al., 2003; Stodden et al., 2006). Perhaps modifying stride length indirectly influences mechanical loading of the throwing arm (Marshall & Elliott, 2000; Reid, Elliott, & Alderson, 2008; Wang, Lin, Lo, Hsieh, & Su, 2010; Wight, Richards, & Hall, 2004). In light of this, the purpose of this study was to challenge pitcher's throwing mechanics by modifying stride length. The aim was to determine whether shortening or lengthening the pitcher's stride influences total body and throwing arm linear momentums; and, specifically to differentiate whether the relative contribution between throwing arm and total body momentums change, as evidenced by the momentum compensation ratio. Perhaps a change in relative momentum between the total body and throwing arm suggests compensatory adaptation owing to altered throwing kinematics and kinetics. It was hypothesized that a change in pitchers' stride lengths would alter peak and mean forward and downward total body linear momentum, which would be evident at each hallmark event and at discrete phases in the pitching cycle. Moreover, the relative percent contribution of the throwing arm to total body momentum (defined as momentum compensation ratios) was expected to differ between stride conditions. Yet frontal plane momentum and momentum compensation ratios were expected to remain unchanged throughout the pitching cycle across stride conditions.

2. Methods

2.1. Subject recruitment

Twenty collegiate and highly skilled high school pitchers (16 right, 4 left handed) were recruited from local collegiate and travel baseball programs using flyers and personal contact. Of the twenty pitchers, one withdrew owing to conflicts with collegiate baseball obligations (15 collegiate, 4 high