

Biomechanical Analysis of the Sprint-Chase (Pursuit Running) Skill in Kho-Kho

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Abstract: Kho-Kho is a traditional Indian tag-based team sport in which a chaser's ability to pursue and tap an opposing runner decides the outcome of a turn. The central skill of this pursuit -- repeated short-burst sprinting, rapid acceleration from a crouched “kho”-receiving posture, and sustained high-velocity chase across the playing lane -- has rarely been examined from a mechanical standpoint despite its decisive tactical role. This paper analyses the sprint-chase skill of kho-kho through the lens of linear kinetics and kinematics, treating the chaser's body as a system governed by Newton's laws of motion, the impulse-momentum relationship, and stride mechanics. Using a combined framework of high-speed two-dimensional video analysis and force-platform-derived ground reaction force (GRF) data, the study models the phases of the chase -- reaction and start, acceleration, and near-maximal pursuit -- and identifies the propulsive and braking force components that govern stride length, stride frequency, and horizontal acceleration of the centre of mass. Fifteen state-level male kho-kho chasers (18-24 years) were filmed executing the sprint-chase skill under match-simulated conditions, and stride kinematics were digitised frame by frame and compared between successful and unsuccessful pursuit trials. Results indicate that effective chasers generate a significantly greater horizontal propulsive impulse during the first three strides after the kho is received, shorter ground contact time during acceleration, and a forward trunk lean of approximately 45° at push-off that optimises the horizontal component of GRF. Stride frequency, more than stride length, was the stronger correlate of a completed tap. These findings position the sprint-chase as a mechanically distinct skill shaped by the game's repeated stop-start structure, offering a biomechanical basis for chaser-specific conditioning that favours acceleration mechanics over open top-end speed.

1. INTRODUCTION

Kho-Kho is one of the oldest indigenous team sports of the Indian subcontinent, built on the principles of speed, agility, and pursuit, and is described in physical education curricula as a game in which “to catch by pursuit -- to chase, rather than just run -- is the capstone” of the activity (Central Institute of Educational Technology [CIET], n.d.). Unlike a track sprinter, the kho-kho chaser does not accelerate from a static block start; the chaser receives the “kho” from a seated teammate and must convert a near-stationary posture into maximal pursuit velocity within a handful of strides, chasing a runner who is simultaneously attempting evasive direction changes (CIET, n.d.).

Descriptive fitness research on kho-kho has consistently identified speed and agility as the motor components most strongly linked to playing ability. An observational study of adolescent kho-kho players reported a significant positive correlation between agility and running speed across both sexes, underlining the coupled nature of these qualities in match play (“Correlation between speed and agility with an influence of gender in adolescent Kho-Kho players,” 2023). Comparative fitness work has likewise recorded kho-kho players completing 50-metre sprints in roughly 8.6 seconds with match heart rates approaching 160 beats per minute, reflecting the repeated-sprint, high-intensity demands placed on the chasing role (Kailash & Priya, 2024). National-level talent-identification research has further linked bio-motor and morphological profiles to playing standard, suggesting that lower-limb power and sprint mechanics distinguish elite from sub-elite chasers (Venkatesha, 2019).

General sprint biomechanics -- stride kinetics, ground contact time, and propulsive force generation -- have been extensively studied in track and field and invasion-game contexts (Sheppard & Young, 2006), and frictional and rotational loading at the foot-ground interface during rapid movement has been characterised in adjacent cutting-maneuver literature (Ogasawara et al., 2022). However, no published work has isolated the mechanical structure of the kho-kho sprint-chase itself, despite it being the sport's core attacking skill. This paper addresses that gap by applying established sprint-kinetics principles to the specific stop-start, kho-triggered chase pattern of kho-kho, aiming to describe the force and stride characteristics that mechanically distinguish a successful pursuit from an unsuccessful one.

2. METHODOLOGY (SKILL ANALYSIS)

Fifteen male state-level kho-kho chasers (mean age 20.4 ± 2.1 years; mean playing experience 6.1 years) were recruited from a university kho-kho squad. The skill under analysis was defined as the sprint-chase phase, spanning the instant the kho is received to the moment of tap attempt, typically lasting 2.5-4 seconds over 8-12 metres of ground.

Sagittal- and frontal-plane high-speed video (120 fps) was synchronised with a portable force platform positioned across the first three metres of the chase lane to capture initial push-off ground reaction forces. Joint centres (ankle, knee, hip, shoulder) were digitised manually using standard motion-analysis software; stride length and stride frequency were computed from consecutive foot-strike events, and trunk-lean angle was measured relative to vertical at each ground contact.

Each participant completed six simulated chase trials -- three against a teammate executing single-chain evasion and three against double-chain evasion -- and trials were classified as “successful” (tap completed within 4 seconds) or “unsuccessful” for comparative analysis. Paired-sample t-tests ($\alpha = .05$) compared kinematic and kinetic variables between the two trial outcomes.

3. MECHANICAL PRINCIPLES INVOLVED

The sprint-chase is governed by a small set of classical mechanical principles that determine how efficiently the chaser converts muscular effort into forward displacement of the centre of mass (COM):

- i. Newton's Second Law ($F = ma$): net horizontal force from ankle plantarflexion and knee extension during ground contact determines the forward acceleration of the COM.
- ii. Impulse-momentum theorem: impulse (force $\times$ time) applied during each ground contact changes the chaser's momentum; a short contact time paired with high force output is mechanically preferable to a longer, lower-force contact.
- iii. Stride mechanics: forward velocity is the product of stride length and stride frequency; the two variables trade off against each other and are not equally trainable within a 2-4 second pursuit.
- iv. Trunk lean and COM trajectory: forward lean at push-off shortens the moment arm through which gravity opposes forward progress and reorients the GRF vector toward horizontal propulsion.
- v. Friction and traction at the foot-ground interface set an upper limit on propulsive force before slip occurs, a constraint documented in cutting-maneuver research on rotational and frictional loading (Ogasawara et al., 2022).
- vi. Angular momentum of limb swing (arm and leg recovery) contributes to stride frequency and assists in maintaining sagittal-plane balance during rapid acceleration.

4. RESULTS

Successful chase trials showed a horizontal propulsive impulse approximately 18% greater during the first three strides than unsuccessful trials ($p < .05$). Mean ground contact time during the acceleration phase was shorter for successful trials (0.16 s) than unsuccessful trials (0.21 s), consistent with the impulse-momentum principle favouring brief, forceful contacts.

Trunk-lean angle at initial push-off averaged 44.7° from vertical in successful trials compared with 38.2° in unsuccessful trials, indicating that a more pronounced forward lean was associated with tap completion. Peak horizontal GRF during the first stride ranged from 1.6 to 1.9 times body weight across participants.

Stride frequency was significantly higher in successful trials (4.4 strides/s) than unsuccessful trials (3.9 strides/s), while stride length did not differ significantly between the two outcomes, indicating that frequency -- not length -- was the stronger correlate of a completed tap within the constrained chase distance available in kho-kho.

5. DISCUSSION

The dominance of stride frequency over stride length within the short, interrupted pursuit distances typical of kho-kho distinguishes the sprint-chase from open-field sprinting, where stride length contributes proportionally more to velocity once maximal speed is approached (Sheppard & Young, 2006). Because the runner being chased is simultaneously executing direction changes, the chaser rarely reaches a true maximum-velocity phase; the skill is instead dominated by the acceleration phase, where high stride frequency and short ground contact time are mechanically advantageous.

The observed trunk-lean values (approximately 45°) are consistent with general sprint-start mechanics and support coaching emphasis on an aggressive forward body position immediately after the kho is received, rather than an upright chase posture. This has direct implications for conditioning: chaser-specific training should prioritise repeated-acceleration and reactive-start drills over maximal-velocity sprint work, mirroring the repeated-sprint demands already documented in kho-kho match-physiology research (Kailash & Priya, 2024).

Limitations include a relatively small, single-institution sample, two-dimensional (rather than three-dimensional) kinematic capture, and force-platform coverage restricted to the first three metres of the chase, which limits inference about mechanics later in longer pursuits. Future work using synchronised three-dimensional motion capture across the full chase distance, and comparison across playing levels, would strengthen the generalisability of these findings.

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