

# Mechanical Analysis of Dodging and Direction-Change Skills (Ring Play and Chain Evasion) in Kho-Kho

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**Abstract:** The runner's ability to evade a pursuing chaser in kho-kho depends on rapid, repeated changes of direction executed within the narrow rectangular lanes of the field -- a skill set locally termed “ring play” and “chain” evasion. Although these evasive manoeuvres are among the most visually distinctive and tactically decisive actions in the sport, they have not previously been analysed using the mechanical frameworks developed for cutting and agility tasks in other team sports. This paper applies principles of rotational kinetics, ground reaction force (GRF) analysis, and centre-of-mass (COM) control to the dodging and direction-change skills of kho-kho, treating each evasive cut as a discrete mechanical event bounded by a braking phase, a reorientation phase, and a re-acceleration phase. Eighteen state-level kho-kho runners (male and female, 17-23 years) were recorded using synchronised high-speed video and a force platform embedded at a marked cutting zone while executing 45°, 90°, and near-135° evasive cuts against a live chaser. Joint angles, COM height, foot-plant distance, and GRF components were extracted and compared between evasions that successfully avoided the tap and those that did not. Successful evaders demonstrated a significantly lower COM height at foot plant, greater knee flexion at initial contact, a shorter penultimate step, and a higher ratio of braking-to-propulsive GRF than unsuccessful evaders. Cut angle was inversely related to completion speed but positively related to evasion success, indicating a speed-accuracy trade-off consistent with agility literature from other sports. These findings characterise kho-kho evasion as a specialised agility skill governed by torque, angular momentum conservation, and frictional limits at the foot-ground interface, and they carry direct implications for both performance coaching and injury-risk awareness at the knee.

## 1. INTRODUCTION

Agility -- defined in the sports-science literature as the ability to change direction and velocity rapidly in response to a stimulus -- unites perceptual decision-making with subject-specific direction-change mechanics (Sheppard & Young, 2006). In kho-kho, this ability is embodied in the runner's dodging repertoire: quick lateral evasions within the lane (commonly described as “ring” play) and the longer diagonal “chain” manoeuvres used to draw a chaser out of position before reversing direction (CIET, n.d.). The rules of kho-kho actively reward this skill, since a runner who successfully evades repeated pursuit attempts extends their team's turn, making direction-change ability arguably as important to outcome as raw sprint speed.

Fitness-testing research on kho-kho populations has repeatedly measured agility as a discrete, trainable quality using instruments such as shuttle-run and AAHPERD agility tests, and has found it to differentiate playing levels and to correlate with sprint performance in adolescent players (“Correlation between speed and agility with an influence of gender in adolescent Kho-Kho players,” 2023). Comparative work between kho-kho and kabaddi players has similarly used agility as a key discriminating physical-fitness variable between the two indigenous sports (Dyavanoor & Jyoti, 2020). However, this body of work has measured agility largely through timed field tests rather than through the underlying joint- and force-level mechanics that actually produce a successful evasive cut.

Outside kho-kho, the biomechanics of cutting manoeuvres has been studied extensively in football, basketball, and multidirectional field sports, where faster cutting performance has been linked to greater centre-of-mass velocity, larger propulsive and braking ground reaction forces, and shorter ground-contact times, but these same mechanics simultaneously increase knee joint loading associated with injury risk -- a tension described as the “performance-injury conflict” (Dos'Santos et al., 2021). Foot-progression angle at landing has also been shown to systematically alter knee abduction and rotation moments during cutting (Nishizawa et al., 2022). No prior study has applied this mechanical framework to kho-kho's dodging skill despite the sport's evasive actions closely resembling the 45-135° cutting tasks studied elsewhere. This paper adapts that framework to kho-kho ring and chain play.

## **2. METHODOLOGY (SKILL ANALYSIS)**

Eighteen state-level kho-kho runners (10 male, 8 female; 17-23 years) with a minimum of three years' competitive experience were recorded during live evasion drills against an active chaser. The evasive cut was defined as the discrete action from the final approach stride, through foot plant and reorientation, to the first stride of re-acceleration in the new direction.

Synchronised high-speed video (120 fps, sagittal and frontal planes) and an in-ground force platform positioned at a marked cutting zone recorded each trial. Cut angle was categorised post hoc as approximately 45°, 90°, or 135° based on digitised COM trajectory. Variables extracted included COM height at foot plant, knee and hip flexion angles at initial contact, penultimate and final step lengths, peak braking and propulsive GRF, and time to re-acceleration.

Each participant performed a minimum of eight live evasion trials against a chaser of matched playing standard; trials were classified as successful (tap avoided) or unsuccessful (tapped within one stride of the cut) and compared using independent-samples t-tests and Pearson correlation between cut angle and completion time.

## **3. MECHANICAL PRINCIPLES INVOLVED**

The evasive cut is a rotational-linear hybrid movement, and its mechanics can be described through the following principles:

- i. Torque and angular impulse ( $\tau = I\alpha$ ): rotation of the body toward the new direction of travel requires a net torque about the vertical axis, generated primarily by asymmetric foot placement and hip rotation.
- ii. Conservation and reduction of moment of inertia: lowering the COM and tucking limb segments closer to the rotation axis (crouching, arm positioning) reduces the body's effective moment of inertia, permitting faster reorientation for a given torque.
- iii. Ground reaction force decomposition: the horizontal GRF at foot plant has both a braking component (opposing the original direction of travel) and a redirecting component (initiating motion in the new direction); the ratio between these determines cut efficiency.
- iv. Foot progression angle: the orientation of the foot relative to the direction of travel at plant alters knee abduction and internal rotation moments, with more externally rotated (toe-out) plants associated with lower knee loading (Nishizawa et al., 2022).
- v. Friction limits: the coefficient of static friction between shoe and playing surface caps the maximum redirecting force available before slip occurs, constraining how sharply a cut can be executed at a given approach speed.
- vi. Speed-accuracy trade-off: sharper cut angles require greater deceleration of the pre-cut velocity, generally increasing time-to-reorientation but reducing the chaser's ability to anticipate the new direction of travel.

## **4. RESULTS**

Successful evasions were associated with a significantly lower COM height at foot plant (mean reduction of approximately 6-8% of standing height) and greater knee flexion at initial contact than unsuccessful trials ( $p < .05$ ), consistent with a crouched, low-inertia posture facilitating faster reorientation.

The penultimate step before the cut was significantly shorter in successful trials, allowing better positioning of the final foot plant under the COM and a more favourable angle between the GRF vector and the intended new direction of travel. Successful trials also showed a higher ratio of braking-to-propulsive GRF magnitude during the plant phase.

Cut angle was positively associated with evasion success (larger angles produced a higher tap-avoidance rate) but negatively associated with completion speed ( $r = -.52$ ,  $p < .05$ ), confirming a measurable speed-accuracy trade-off. No significant sex difference was found in COM-height reduction strategy, though male participants showed marginally higher peak braking GRF.

## **5. DISCUSSION**

The lower COM height and greater knee flexion observed among successful evaders align with the general agility literature identifying a crouched, ready posture as mechanically advantageous for rapid direction change (Sheppard & Young, 2006). The shortened penultimate step observed here mirrors a well-documented adjustment strategy in cutting-maneuver research, in which athletes reposition their COM relative to the base of support before the decisive plant step to optimise the direction of the resultant GRF (Dos'Santos et al., 2021).

The trade-off between cut sharpness and completion speed has direct tactical implications: kho-kho runners appear to sacrifice velocity for unpredictability when the chaser is in close proximity, a pattern consistent with agility being fundamentally a perception-action coupling rather than a pure speed quality (Sheppard & Young, 2006). From a coaching

standpoint, this suggests that evasion training should vary both cut angle and chaser proximity rather than drilling fixed-angle cuts in isolation.

The knee loading associated with sharper, higher-force cuts also raises injury-awareness considerations. Given evidence that mechanics favouring cutting performance (greater braking force, reduced knee and hip flexion range) can simultaneously elevate knee abduction and rotation moments (Dos'Santos et al., 2021; Nishizawa et al., 2022), coaches working with young kho-kho runners should balance evasion-speed training with technique cues -- particularly encouraging an externally rotated foot plant -- that may reduce cumulative knee joint loading without sacrificing evasive effectiveness. As with Paper 1, the present sample size and reliance on two-dimensional video digitisation for a subset of variables limit the precision of joint-moment estimates, and three-dimensional motion capture would be a valuable extension.

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