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Systematic Review of Literature: Biomechanical Analysis of the Long Jump Hitch-Kick Technique Using Kinovea

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Abstract: ***A common flight strategy for the long jump is the hitch-kick, which assists the athlete in preparing for a good landing and controlling the forward angular momentum generated at takeoff. This systematic review included open-access studies published from 2016 to 2026, which specifically stated Kinovea as the video-analysis software used for the biomechanical or kinematic analysis of the long jump. Eight qualifying studies were combined in total. The other investigations provided supporting information on takeoff, center-of-mass behavior, joint angles, landing mechanics and technique evaluation. Two specifically compared or evaluated the flight mechanics of the hitch-kick. The most convincing direct evidence is that the hitch- kick, compared with the hang technique, can generate better center-of-mass trajectory features, jump distance, and multiple positive take-off/flight metrics in a single-subject comparison study. In larger long-jump research, take-off velocity, take-off center of mass height and knee- angle parameters have all commonly been linked to performance. However, the evidence base is heterogeneous, with predominance of descriptive/correlational designs, 2-D analysis of video in the sagittal plane and small samples. Therefore, a pooled effect-size meta-analysis was not warranted.***

Keywords: Long jump, Hitch-kick, Kinematics, 2D motion capture, Video based analysis

1. Introduction

The long jump performance is characterized by an approach run, takeoff, flight, and landing sequence. Biomechanical study is useful in that success depends on the ability of the athlete to efficiently convert horizontal approach velocity to projectile motion while controlling body rotation during flight. (Samson et al., 2021) These phases, particularly joint angles, center of mass location, takeoff velocity and phase specific method factors are still under investigation through two-dimensional video in recent Kinovea experiments. (Jasminan et. al., 2021)

The athlete employs the hitch-kick flight-phase technique to manage the body configuration and the consequences of forward rotation prior to landing through cycling the arms and legs following take-off. (Ai-Qutami et al., 2019) The closest comparisons found in the literature for this review were the case study of Jordan, of Al-Qutami and Kilani (2014), and the Sri Lankan study of Jasminan and Chandana (2014). The former compared hang and hitch-kick using Kinovea; the latter compared 2½ hitch-kick, hitch-sail and hang using residuals of the trajectory of the centre-of-mass. (Ai-Qutami et al., 2019) These two investigations are therefore the best support for the present review question. (Jasminan et. al., 2021)

Kinovea is highly relevant to this area of study as it enables frame by frame analysis and 2D measurement based on ordinary video. (Pandi et al., 2019) The investigations reveal its possible uses in phase identification, take-off variables, joint-angle measurement, center-of-mass tracking and flight trajectories. (Samson et al., 2021) While video perspective, calibration, camera orientation, frame rate and marker recognition can affect measurement accuracy, Kinovea is attractive for instructional settings and field-based sports biomechanics. (Jasminan et. al., 2021)

2. Review Questions

- What biomechanical aspects were studied in long-jump research with Kinovea from 2016 to 2026?
- What is the evidence that the hitch-kick works biomechanically?
- What aspects of takeoff, flying, and landing are most reliably linked to long-jump performance?
- What are the research needs and methodological limitations that should inform future Kinovea-based hitch-kick studies?
- These questions were designed to differentiate direct hitch kick data from more general Kinovea long jump data as most of the papers retrieved did not isolate the hitch kick method as their only independent variable. (Jasminan et. al., 2021)

3. Methods

Search Strategy: A systematic literature search was performed using the keywords “long jump,” “hitch-kick,” “biomechanics/kinematics,” and “Kinovea” via web-accessible open-access journal pages, article PDFs, and scholarly-indexed records. The time period was from January 2016 through August 2026. The search was weighted toward publicly available full text and primary research. Exact database-level record counts were not produced as the current search tool did not yield a repeatable

exported Google Scholar result set. Inclusion was determined by explicit confirmation of Kinovea's citation in the study's long-jump analysis. (Sangucho Hidalgo et. al., 2022) (Suhartoyo, 2022)

The eligibility requirements were as follows: (1) Human long-jump analysis, (2) Biomechanical, kinematic or method analysis, (3) Kinovea specifically as the long-jump video-analysis software, (4) Sufficient readily available data to extract the sample, variables and main findings, and (5) Publication year 2016–2026. Studies that reported only the Kinovea without long-jump data, that studied only the standing long jump and not the athletics event, or that did not use Kinovea for the long-jump analysis were excluded. (Sangucho Hidalgo et. al., 2022)

Furthermore, a stringent software requirement resulted in the omission of many potentially relevant contemporary studies. For instance, a 2026 competition-based study that used both Dartfish and Kinovea was excluded from the core evidence collection under the existing "Kinovea-only" limitation. (Pengfei Wei et. al., 2026) Similarly, a PhD thesis in 2018 described Kinovea in combination with Max Pro/3D analysis; therefore it was not considered as Kinovea only study. (Pengfei Wei et. al., 2026)

4. Study Selection

Of the nine records identified as potentially relevant during the focused search, eight met the final strict inclusion criterion used for the primary synthesis. For a 2020 study by Reddy and Singh that was excluded from the main evidence table, the available procedures identify Max Traq 2D/Silicon Coach Pro-7 instead of Kinovea for the kinematic analysis. This emphasizes the need for software verification, not just abstract or title. (Singh, 2020)

Selection Stage	n	Reason/interpretation
Potentially relevant records located	9	Targeted open-access/scholarly search; not a database- export count
Included in primary synthesis	8	Kinovea explicitly used for long-jump analysis
Excluded after software verification	1	Reddy & Singh (2020): Max Traq 2D/Silicon Coach Pro-7 reported
Quantitative meta-analysis	0	High heterogeneity in technique, outcomes, samples and designs

5. Characteristics of Included Studies

Study	Year	n	Technique	Kinovea/software	Design
Al-Qutami & Kilani (2019)	2019	1	Hang vs. hitch-kick	Kinovea 2014	Comparative kinematic case study
Pandi (2019)	2019	10	General long jump	Kinovea	Descriptive/correlational 2-D analysis
Jasminan & Chandana (2021)	2021	12	2½ hitch- kick, hitch-sail, hang	Kinovea 0.9.3	Comparative 2-D kinematic analysis
Samson, Amanu & Khan (2021)	2021	20	General long jump	Kinovea	Cross-sectional explanatory analysis
Sangucho Hidalgo, Rivadeneira Arias & Aguilar Morocho (2022)	2022	1	Paralympic long jump	Kinovea	Descriptive, analytical mixed case study
Sugiharta, Samodra & Perdana (2022)	2022	11	General long jump	Kinovea	Quantitative descriptive survey
Suhartoyo et al. (2022)	2022	15	Squat style	Kinovea	Quantitative descriptive analysis
Chakraborty & Sajwan (2024)	2024	10	General long jump	Kinovea	Quantitative correlational analysis

The evidence base was geographically diverse with studies from Jordan, India, Sri Lanka, Ethiopia, Ecuador/Paralympic sport, Indonesia and university sports in India. (Ai-Qutami et al., 2019) Sample sizes varied from case studies with one athlete to 20 people. (Samson et al., 2021) This is an important distinction as although single-athlete comparisons can provide detailed technical information, they are not able to show the superiority of a certain flying style at the population level. (Ai-Qutami et. al., 2019)

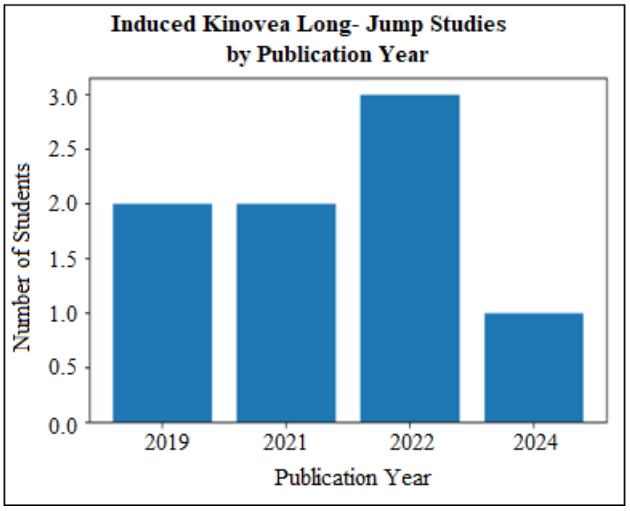

Figure 1: Publication-year distribution of the eight included Kinovea-based long-jump studies. Values are synthesized from the included-study table.

In 2021–2022, we observe a clustering in the publishing pattern, in which several works used accessible 2-D video analysis to study the long jump technique. Kinovea is still used for field- based biomechanical examination as a 2024 study used the same inexpensive technique to linearize

kinematic data (Jasminan et. al., 2021). (Chakroborty et. al., 2024)

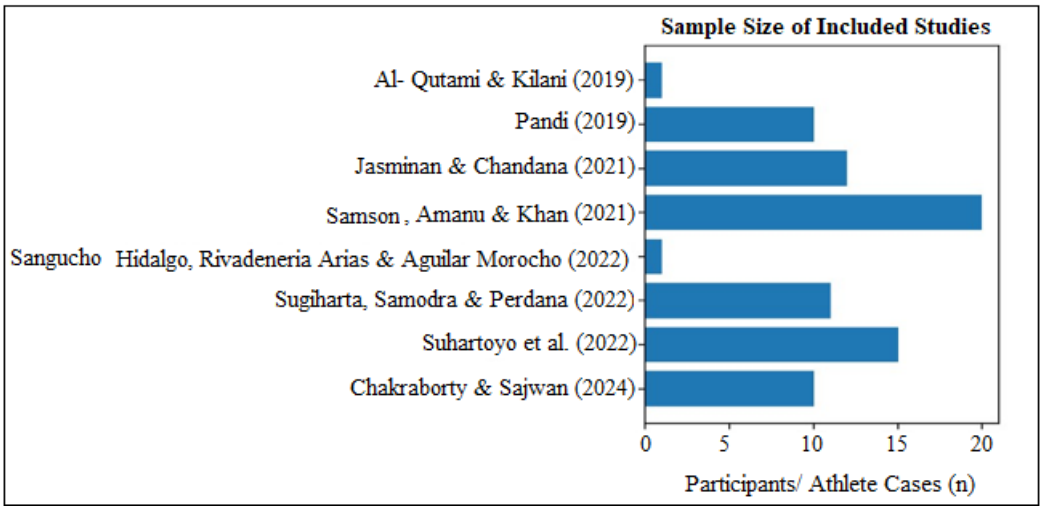

Figure 2: Sample size/case size across included studies. Case-study samples are retained as n=1 because they represent one athlete

6. Biomechanical Findings

6.1 Direct evidence on hitch-kick

The most convincing evidence is the comparison of hang and hitch-kick by Al-Qutami and Kilani. In both cases, the best Jordanian athlete made six attempts and the distance recorded was 7.48 meters. The researchers used Kinovea 2014 to analyze leaping distance, flying distance, downward distance, backward distance, center-of-gravity height, launch velocity, and projectile angle. The authors found that the hitch-kick was preferred for actual jump distance, take-off height, projectile angle, horizontal and vertical take-off velocity, total projectile height and total flight time, but the backward distance was preferred for the hang approach. Kilani, A. & Al-Qutami, S. (2019).

The Al-Qutami and Kilani findings, however, should be taken as a case study rather than a sign that hitch-kick is generally better. Only one athlete was used so the discrepancy can be due to the individual athlete's anthropometry, strength, technical skill, preferred flying method and daily performance. Although the statistical generalizability of the research remains limited, it is useful in that it highlights the practical considerations that should be assessed in a larger hitch-kick investigation in the future. (Ai-Qutami et. al., 2019)

At the group level, Jasminan and Chandana are more convincing in comparison data. Twelve men long jumpers were equally divided into three groups: hang, hitch-sail, and 2½ hitch-kick. Four 50-Hz cameras recorded the airplane from takeoff to touchdown and the center-of-mass coordinates were determined frame by frame using Kinovea 0.9. Third. The authors compared the actual displacement of the projectile and the expected displacement. They found significant differences between techniques for the horizontal and vertical residuals. (Jasminan et. al., 2021)

In the Sri Lankan study, the residual horizontal displacement was the least in hitch-kick, followed by hitch-sail and hang. In terms of lowest vertical residual, hitch-kick was also very different from the other two approaches. This pattern is consistent with the notion that hitch- kicking may help some athletes maintain their center-of-mass trajectory closer to the projectile path. The present study did not show that hitch-kicking results in an increased absolute jump distance for an athlete, but rather, that the trajectory was more consistent. (Jasminan & Chandana, 2021).

6.2 Take-off mechanics

Kinovea literature often mentions take-off mechanics as a major factor in long-jump performance. Pandi (10 athletes) studied, the angle of the take-off leg had a positive correlation with the performance, the take-off phase had a negative correlation with the take-off time and the knee angle did not significantly correlate with the performance. The results show that the mechanical state generated at the moment of contact with the board should be considered when evaluating the flight mode. (Pandi et. al., 2019)

Samson et al. reported a large correlation between knee angles during takeoff preparation and takeoff and long jump performance. The regression model showed R^2=.676 and the reported correlations for preparation-phase knee angle and take-off knee angle were r=-0.67 and r=- 0.53, respectively. So, the contact mechanics and the preparation of the take-off explained a large portion of the performance variability in this group. However, the authors also noted that the effect size of the individual contribution was small. (Samson et. al., 2021)

Chakraborty and Sajwan provide further evidence for the importance of the take- off state. In 10 male long jumpers, take-off velocity had a stronger positive relation of r=.866 (p=.001), while the height of the center of gravity at take-off was related to performance at r=.788 (p=.007). These results support the hypothesis that a good takeoff is the basis for a successful hitch-kick and not the appropriate approach velocity and takeoff mechanics. (Chakroborty et. al., 2024).

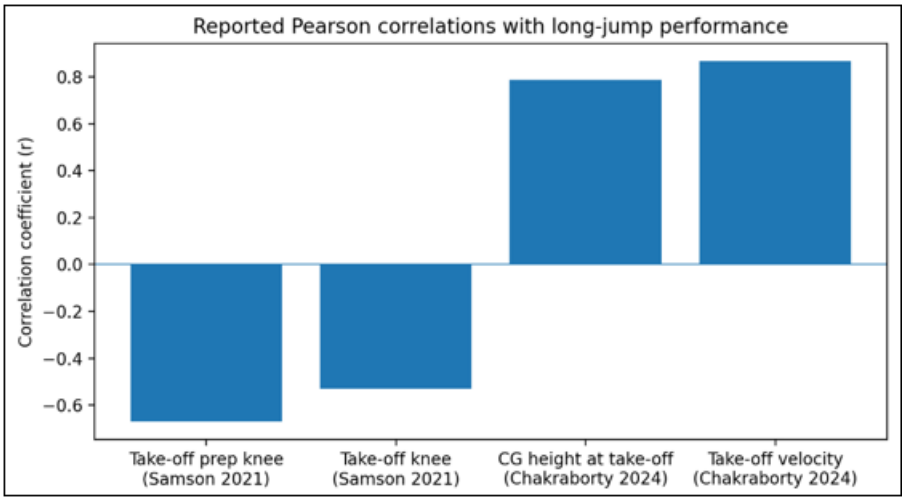

Figure 3: Selected reported correlations with long-jump performance. Only exact coefficients reported in the accessible evidence are plotted; the values are not pooled effect sizes

6.3 Centre of mass and flight control

Center-of-mass control is particularly crucial for hitch-kicks since the athlete is in the air and cannot generate a conventional ground response force to instantly change whole-body translation. The Kinovea study solved this issue with two-dimensional tracking. Residuals of predictions of projectile motion and frame-by-frame center of mass data were used by Jasminan and Chandana, whereas Chakraborty and Sajwan measured the center of gravity height during takeoff, flight and landing. (Jasminan et. al., 2021)

The data show a greater correlation of takeoff conditions with performance than the simple vertical height of the center of mass during flight. Chakraborty and Sajwan found a very weak, non-significant association for flight CG height (r=.026, p=.943), but both take-off CG height and take-off velocity were significant. (Chakroborty et al. 2024) This difference matters for hitch-kick research: one should assess the leg-cycling action as a way of controlling rotation and preparing the landing, not of generating new horizontal velocity in the air. (Jasminan et. al., 2021)

Kinovea has also been used to evaluate phase-specific joint angles. Angles of the ankle, knee, shoulder and elbow were measured during takeoff preparation, takeoff, flight and landing (Samson et al., 2021); average values for amortization, alignment, leg swing and drift phases were presented by Sugiharta et al. (Sugiharata et al., 2022). These studies demonstrate how Kinovea can be used in a realistic way to compare athletes to reference data and identify technical aberrations. These studies also highlight important discrepancies in terminology and phase definitions between studies. (Samson et. al., 2021)

The study of Suhartoyo et al. in Indonesia, the highest take-off angle (22.7°) was related to the 5.32 meters performance in the squat-style flying technique. Although there is not direct confirmation of hitch-kick, this is contextual evidence that take-off angle is still an important consideration when evaluating any flying type. It should not be used to establish a normative hitch-kick angle because the technique and athlete population differ. (Suhartoyo, 2022)

6.4 Special-Population evidence

When examining the long-jump technique of Paralympic medalist Kiara Rodríguez, Sangucho Hidalgo and colleagues especially used Kinovea for biomechanical examination. For this descriptive and analytical mixed case study, the ANCOVA result was p=.408. The technical gesture of the athlete did not satisfy the authors' requirements in terms of the rating. Since the study is based on one single Paralympic athlete, its contribution to hitch-kick research is mainly analytical and personalized and not normative. (Sangucho Hidalgo et. al., 2022)

7. Evidence Synthesis Table

Study	n	Technique	Main variables	Main evidence
Al-Qutami & Kilani (2019)	1	Hang vs. hitch-kick	Jumping, flight, downward and backward distances; CG height; take-off velocity; projectile angle	Hang demonstrated a larger rearward distance; hitch-kick demonstrated a bigger jump distance and take-off height, a 4° greater projectile angle, a higher horizontal/vertical take-off velocity, and a longer total flight duration.
Pandi (2019)	10	General long jump	Take-off phase, take-off time, take-off leg angle, knee angle	Performance was favorably correlated with take-off leg angle, negatively correlated with take-off phase and take- off time, and not substantially correlated with knee angle.
Jasminan & Chandana (2021)	12	2½ hitch-kick, hitch-sail, hang	Centre-of-mass coordinates and horizontal/vertical displacement residuals	Hitch-kick yielded the lowest horizontal and vertical residuals; the horizontal residuals ranked hitch-kick < hitch-sail < hang, while the vertical residuals were substantially different from the other methods.
Samson, Amanu & Khan (2021)	20	General long jump	Ankle, knee, shoulder and elbow angles across take-off preparation, take-off, flight and	Performance was linked with both take-off-preparation knee angle (r=-0.67) and take-off knee angle (r=-0.53); the two knee-angle predictors accounted for 67.6% of the variance (R^2=.676).

			landing	
Sangucho Hidalgo, Rivadeneira Arias & Aguilar Morocho (2022)	1	Paralympic long jump	Technical/biomechanical execution variables	The long-jump execution method was assessed using Kinovea; ANCOVA yielded p=.408, and the authors noted a poor technical gesture.
Sugiharta, Samodra & Perdana (2022)	11	General long jump	Amortization, alignment, leg swing and drift angles	The reported mean phase angles were 141°, 166°, 62°, and 168°, respectively; the results were compared to benchmark values for males and females.
Suhartoyo et al. (2022)	15	Squat style	Take-off angle	The research concentrated on the squat-style long jump, with a performance of 5.32 meters and a recorded maximum take-off angle of 22.7°. It is not direct hitch- kick proof, but it does offer contextual take-off evidence.
Chakraborty & Sajwan (2024)	10	General long jump	CG height at take-off, flight and landing; take- off velocity	Performance was substantially linked with CG height at takeoff (r=.788, p=.007) and takeoff velocity (r=.866, p=.001); flight CG was not significant (r=.026, p=.943).

8. Methodological Quality and Limitations

Study	Descriptive quality score*	Key appraisal
Al-Qutami & Kilani (2019)	3/6	Direct technique comparison; n=1; limited generalizability
Pandi (2019)	4/6	Clear Kinovea method and correlations; small sample
Jasminan & Chandana (2021)	5/6	Clear camera protocol, Kinovea version and technique groups; n=12
Samson et al. (2021)	4/6	Clear Kinovea/statistical procedure; cross- sectional, availability sampling
Sangucho Hidalgo et al. (2022)	3/6	Useful Paralympic case; single athlete and limited inferential scope
Sugiharta et al. (2022)	3/6	Clear descriptive angles; limited methodological detail and benchmark dependence
Suhartoyo et al. (2022)	4/6	Clear purposive sample and Kinovea angle analysis; squat style only
Chakraborty & Sajwan (2024)	4/6	Clear variables and correlations; n=10 and limited reporting detail

**This is a descriptive reporting appraisal created by the author for this review and is not a validated risk-of-bias tool. Assesses design/sample clarity, Kinovea procedure, variables/statistics and reporting limitations.*

The largest methodological weakness of the evidence base is the small and heterogeneous sample. (Ai-Qutami et al., 2019) Two direct hitch-kick studies are quite illuminating, even if they only include one athlete, or four athletes per technique group. Jasminan et al., 2021 Many larger studies also use convenience or purposive sampling. (Samson et al., 2021) Although these designs are suitable for exploratory sports biomechanics, they are not sufficient to draw definite conclusions about the optimal hitch-kick arrangement. (Jasminan et. al., 2021)

A second disadvantage is the predominance of two-dimensional analysis. Sagittal-plane video can accurately estimate angles and displacement, but does not measure three-dimensional segment rotation, frontal/transverse-plane motion, and whole-body angular momentum. This is important for the hitch-kick method as it is essentially swinging the arms and legs together around the center of gravity of the body. (Jasminan et. al., 2021)

A third disadvantage is inconsistent camera frame rate, calibration and reporting. Jasminan and Chandana recorded four cameras at 50 Hz, camera location and a calibration pole precisely, but other studies provide less detailed information. Inconsistency of camera location, calibration distance, frame rate and methods of digitization make it difficult to compare angles or velocities directly between studies. (Jasminan et. al., 2021)

9. Research Gap and Future Directions

The most obvious gap in research is the lack of large-scale prospective studies separating out the mechanics of the hitch-kick and examining the association between changes in individual flight characteristics and actual competition distance. Jasminan et al. (2021) determined that there is a lot of evidence that hitch-kick is a potentially useful strategy, but not enough to identify the optimal timing of the flight-phase, precise joint-angle sequence or universal best number of “kicks.” (Ai-Qutami et. al., 2019)

A more reliable future design would involve the recording of elite and sub-elite jumpers using standardized sagittal-plane video with a documented calibration frame, high frame rate, constant camera height and distance, and well-defined events such as penultimate contact, final contact, board touchdown, takeoff, peak COM, first hitch-kick leg exchange, landing preparation, and sand contact. Kinovea can then be used to consistently derive joint angles, segment angular displacement, COM coordinates, takeoff velocity estimates, flight time and phase timing. (Jasminan et. al., 2021)

Future research should distinguish performance into the approach/takeoff component and the flight/landing component. (Chakroborty et. al., 2024) The present data indicate strong relationships of performance with take-off velocity and take-off COM height, but the hitch- kick appears most important for controlling rotation and preparing

for landing. A multivariable model could thus be used to determine whether hitch-kick parameters have any explanatory power after controlling for approach velocity and takeoff mechanics. (Samson et. al., 2021)

10. Practical Conceptual Model

Phase	Biomechanical objective	Kinovea variables
Approach run	High controllable horizontal velocity	Approach velocity, rhythm, last-step characteristics
Take-off preparation	Prepare COM and reduce unnecessary velocity loss	Knee angle, ankle/hip position, penultimate/last- step timing
Take-off	Convert part of horizontal velocity into vertical velocity	Take-off velocity, take-off angle, COM height, contact time
Early flight	Control forward rotation	Hitch-kick leg/arm sequencing, segment angles
Mid/late flight	Maintain effective body configuration	COM trajectory, angular displacement, phase timing
Landing	Maximize measured distance without excessive backward displacement	Leg extension, trunk position, landing angle and backward fall

This conceptual model integrates the elements that are actually examined in the offered Kinovea literature (as opposed to imposing an external normative paradigm. In 2021, Jasminan et al. It considers hitch-kick mainly in the flight-control part of the event, while acknowledging that its visible effectiveness depends on the take-off condition created just before to flight. (Ai- Qutami et. al., 2019)

11. Conclusion

Literature from 2016 to 2026 based on Kinovea gives preliminary evidence for the biomechanical relevance of the hitch-kick technique in long jump. In a single-athlete comparison, hitch-kick can perform better than hang on several take-off/flight parameters in 2021. In a small group study, hitch-kick can provide lower center-of-mass trajectory residuals than hitch-sail and hang. These are the most persuasive direct consequences. (Ai-Qutami et al., 2019) A more detailed analysis using Kinovea revealed significant performance correlations between the take-off velocity, the take-off COM height and the knee-angle characteristics. (Chakroborty et. al., 2024)

But the data are to be viewed as exploratory, not definitive. As stated by Jasminan et al. (2021), the limited samples, the case-study designs, the different definitions of the methods and the inconsistent reporting of camera/calibration methodologies, as well as the predominance of 2- D research, hinder the development of a reliable pooled estimate or a universal hitch-kick biomechanical model. Thus, the most logical conclusion is that Kinovea is a useful field-based instrument for studying hitch-kick kinematics, but larger and more standardized studies are needed to establish trustworthy performance correlations and technique-specific standards. (Jasminan et. al., 2021)

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