Physical Education Theory and Methodology
Теорія та методика фізичного виховання

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original Scientific Article

Assessing the Effects of Isoinertial Eccentric Training on Kinetic Stability, Feinting Ability, and Kicking Power in Youth Rugby Players: A Randomized Controlled Study

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: June 02, 2025
Published: July 30, 2025

DOI: 10.17309/tmfv.2025.4.05

Abstract

Background. Rugby requires explosive strength in the lower body, agility, and stability, with eccentric actions being key in performance and in the prevention of injuries. Although isoinertial training has shown promise in enhancing eccentric strength in other sports, its effects on rugby-specific skills remain understudied.

Objectives. This study aimed to examine the impact of a six-week isoinertial strength training program on improving kinetic stability, feinting ability, and kicking power in youth rugby players.

Materials and methods. Forty male athletes (age: 15.2 ± 0.6 years) were randomized into two groups: an experimental group (EG; n = 20) performing isoinertial training twice weekly for lower extremity strength, and a control group (CG; n = 20) who continued with traditional training. Pre- and post-intervention evaluation included the Y-Balance Test (kinetic stability), Fitlight-driven feinting tests, and radar-measured kicking speed.

Results. The EG showed significant improvements in the Y-Balance score on the right leg (+4.5 %, $p < 0.001$) and left leg (+3.9 %, $p < 0.001$), faster feinting reaction times (−3.6 %, $p = 0.005$), and enhanced kicking power (+9.8 %, $p < 0.001$) when compared to the CG, which had no substantial changes ($p > 0.05$).

Conclusions. The study concludes that isoinertial eccentric training enhances rugby-specific performance metrics, likely mediated by improved neuromuscular control and eccentric strength. Therefore, these findings support the inclusion of isoinertial training in youth rugby conditioning programs to enhance agility, stability, and power.

Keywords: isoinertial training, kinetic stability, kicking velocity, feinting agility, reactive strength, power development.

Introduction

Rugby is a high-speed contact sport presenting short-burst running, tackling, fast turn with loads on either leg, kicking, and specific physical skills: maximal strength, power, agility, and neuromuscular control, which predominantly involve lower limbs (Mužek, 2015). Combat between muscle strength development and concussive-aggressive impacts renders these specific actions a potential risk for hamstring strains (Warren et al., 2014) and ligament injuries, which may also pose an imbalance of agonist-antagonist forces (Byrne & Eston, 2002). Historically, traditional rugby training has concentrated on concentric muscle contractions (for example, squatting and leg-pressing) for strengthening and power development (Randell, 2011). Although beneficial, the downside of this approach is that it now ignores the critical eccentric phase (lengthening) of muscle action (Harris-Love et al., 2017), which is required for deceleration, stability, and injury resilience. Eccentric contractions produce 20-60 % greater force than concentric actions and play a vital role in any sport with sudden changes in direction, such as rugby (Douglas et al., 2017). Yet current strength programs in

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rugby Favor concentric overload, leaving eccentric strength adaptations poorly trained for performance enhancement and injury prevention (Harris-Love et al., 2021).

Eccentric training has gained popularity with enhanced muscle hypertrophy, tendon stiffness, and neuromuscular efficiency (Harris-Love et al., 2021). Contrary to conventional resistance training that focuses on concentric lifting, (Majeedkutty, 2018) eccentric-focused training emphasizes force absorption and control mechanisms critical to the rugby player, who frequently decelerates and changes direction under load. Eccentric training benefits have been demonstrated in sports such as football and basketball: Sprint performance (Majeedkutty, 2018), Vertical jump and power output (McNeill et al., 2019), and Resilience to injury, specifically hamstring strains (Ali & Leland, 2012). Nonetheless, the main bias in eccentric training in rugby has remained largely unexplored, with most research on Nordic hamstring exercise as opposed to dynamic, sports-specific eccentric loading (Chavarro-Nieto et al., 2022). This marks a significant shortcoming, considering the explosive deceleration, reactive agility, and high velocity kicking unique to rugby.

Flywheel resistance systems are unique in their variable resistance that secures performance output from the athlete (Nylen et al., 1994). Unlike traditional weights, flywheels produce eccentric overload automatically, which ensures maximal loading during the braking phase of each movement (Correa & Lindberg, 2020). This system has been shown to: 1.) Create an excellent eccentric strength preparation that is more excellent than conventional resistance training (Coratella & Schena, 2016), 2.) Improve the rate of force development (RFD), which is essential for activities like sprinting and kicking (Maffiuletti et al., 2016), 3.) Increased muscle activation in stabilizer muscles protects the joint (Fonseca et al., 2004). While promising, few studies have assessed inertial training in rugby, especially concerning the skills of kicking velocity, feinting agility, and postural stability under dynamic conditions (Kenville et al., 2021). Most literature focuses on general athletic performance, disregarding the peculiar biomechanical demands of rugby.

Eccentric Training Studies Up to Now Most studies on isoinertial training have been done on football and basketball action and sprinting investigations (Harden et al., 2022), hardly extending to rugby. Within rugby, there is a higher need for collision resistance, multi-directional agility, and explosive kicking than in any other sport. However, whether isoinertial training contributes to these abilities has not been addressed. Limited Focus on Youth Rugby Players (Pokrajčić et al., 2018) Most eccentric training studies have focused mainly on elite or professional athletes (Burgos-Jara et al., 2023) and thus overlook youth players at an essential stage of neuromuscular development. Youth athletes have been said to have more remarkable neural plasticity (Faude et al., 2017); therefore, they may react differently to eccentric stimuli than adults. Inadequate Investigation of Measurement Performance Specific to the Sport on the part of the previous studies, standard measures would be used (such as vertical jump or 1RM squat) instead of rugby performance skills (for example, kicking power, feinting ability, kinetic stability during contact) (Widenhoefer et al., 2019). We need applied research directly assessing the transfer of rugby performance on the field as influenced by isoinertial training (Brearley & Bishop, 2019). Such studies could provide valuable insights into how specific training modalities impact the unique demands of rugby, ultimately leading to more effective coaching strategies and improved athlete performance at all levels.

The gaps in current training methodologies are what they are, and this study mainly intends to analyze the effects of a 6-week isoinertial training program on the performance indicators pertinent to the rugby athlete. The study plans to assess changes in kinetic stability through the Y-Balance Test, the feinting agility with Fitlight reaction time, and the kicking velocity measured by radar-based ball speed. These results will be conferred with those generated through classical rugby training to provide insights into whether isoinertial training allows additional physiological and performance adaptations. It is postulated that the experimental group under is inertial training will have statistically significantly more significant increases in all variables measured than the control group. Additional hypotheses suggest that an eccentric overload component of isoinertial training may enhance neuromuscular control, improving stability and agility in rugby-specific movements.

This study is the first to investigate isoinertial eccentric training with a specific focus on sport-specific performance outcomes within the context of youth rugby players. The expected findings will provide invaluable information to assist strength and conditioning coaches with evidence-based recommendations to fine-tune training protocols tailored explicitly for the joint demands of rugby. Moreover, the study will emphasize the role of eccentric loading not simply as a method for optimizing performance but as a fundamental construct of injury prevention for collision sports. By addressing flywheel training in a rugby setting, the proposed research will contribute meaningfully to the currently developing literature around isoinertial methods and fill an essential gap in training sciences relevant to contact-type athletic disciplines.

Materials and Methods

The study conducted an RCT to determine how a 6-week isoinertial eccentric training program would influence training outcomes like kinetic stability, feinting ability, and kicking power in young rugby players. Forty subjects (males, age 15.2 ± 0.6 years) were identified randomly and distributed to experimental or control subjects. The first group performed flywheel-based training (Wonders, 2019) (kBox4), while the other group continued the traditional rugby drills of practice in the building. The name given to them is CG, and it was for n 20. The EG completed twice-week training sessions with the exercise's squats (4×6 reps), lateral lunges (3×8 re exercises and Romanian deadlifts (4×6 reps) with the progressive load of eccentric overload while the CG strictly implemented standard training without all other interventions. Performance measures included: For kinetic stability - the Y-Balance Test (YBT) with reach distances normalized to the leg length (Yam & Fong, 2019); Feinting ability tested using Fitlight technology (reaction time and accuracy); (Badau & Badau, 2022) Kicking velocity as determined by radar gun (Bushnell Velocity, ±0.1 m/s) (Parsonage et al., 2014).

Statistical Analysis

The statistical analysis was performed on SPSS version 23, and normality was assumed based on the results of the Shapiro-Wilk tests ($p > 0.05$). Within-group differences were analyzed using paired t-tests, while differences between the post-intervention values of EG and CG were analyzed using independent t-tests. Effect sizes (Cohen's d) were calculated to measure the magnitude of Intervention's. A probability value of $p < 0.05$ was considered significant. The study was conducted following ethical guidelines (Declaration of Helsinki), and informed consent was obtained from all participants and guardians.

Results

The 6-week isoinertial eccentric training intervention resulted in significant improvements across all measured performance metrics with youth rugby players. The baseline characteristics showed no significant differences between groups (Table 1), which confirmed a successful randomization ($p > 0.05$ for all demographic variables).

Table 1. Participant Characteristics

Variable	EG (n = 21) mean ± SD	CG (n = 21) mean ± SD	p
Age (years)	15.20 ± 0.6	15.30 ± 0.7	0.621
Height (cm)	165.4 ± 2.3	166.10 ± 2.1	0.302
Weight (kg)	58.70 ± 5.6	59.20 ± 6.1	0.782
BMI (kg/m^2)	21.50 ± 2.1	21.40 ± 2.3	0.885

*(Values presented as mean ± SD; Independent t-tests showed no baseline differences, $p > 0.05$)

In age Distribution EG (M = 15.2, SD = 0.6) and CG (M = 15.3, SD = 0.7) showed aligned age distributions. Independent-samples t-test revealed no significant effects ($t_{(40)} = -0.50$, $p = 0.621$). The very small p-value (>0.05) certifies the successful randomization with respect to age. Anthropometric Measures, Mean heights differ by only 0.7 cm between groups (EG = 165.4 cm vs CG = 166.1cm). The non-significant t-test results suggest comparable stature ($t(_{40}) = -1.05$, $p = 0.302$). For the mean difference (-2.08 to 0.68 cm), the 95% confidence interval includes 0. Weight Characteristics, Weight distributions were almost similar (EG = 58.7 kg vs CG = 59.2 kg). The trivial non-significant result (0.5 kg) was $t(40) = -0.28$, $p = 0.782$). Effect size (Cohen's d = 0.09) shows between-groups negligible difference. BMI Analysis Both groups were categorized according to BMI scales but were normal (EG = 21.5 vs CG = 21.4 kg/m^2). The tiny difference (0.1 kg/m^2) was not significant ($t_{(40)} = 0.15$, $p = 0.885$). This small confidence interval (-1.13 to 1.33 kg/m^2) means measuring this very precisely. Methodological Implications, the homogeneity between groups (all $p > 0.30$) confirms that randomization was successful.

These groups are very similar at baseline, increasing internal validity by reducing confounding. Very small standard deviations (especially height, which is ±2.3 cm) indicate a narrow clustering of data. The results meet the equivalency assumption for groups that is required for further analysis with ANCOVA. Clinical Relevance the sample represents standard anthropometrics for developing adolescent rugby players. The narrow age range (15.2-15.3 years) controls for differences in development. BMI values indicate acceptable weight status for athletic purposes. Statistical Power Considerations Posthoc power analysis ($\alpha = 0.05$, n = 21/group) indicates >80 % power to detect: Height differences ≥2.8cm Weight differences ≥4.1kg BMI differences ≥1.8 kg/m^2. Thorough baseline analysis makes sure that any differences observed post-intervention stem directly from the training intervention and not owing to differences between the groups. By themselves, the close clustering of anthropometric data (little SDs) increases the internal validity of the study while also supporting sound comparisons of performance afterward.

Considering the results, a significant positive change was seen in all performance indicators for the experimental groups in the post-testing, following the 6-week isoinertial training intervention. Kinetic stability, measured using the Y-Balance Test, noted a 4.5% increase in right leg performance (from 58.2 % to 60.8 %) with an extremely large effect size ($d = 1.77$, $t = -8.105$, $p < 0.001$), where negative t-value substantiated consistent improvement across all participants. The interval of confidence 95 % [1.92 %, 3.28 %] indicates enhanced precision in estimating these values. Left leg performance increased similarly at 3.9 % (66.5 % to 69.1 %) with near-perfect effect size ($d = 1.95$), indicating a clinically meaningful change towards injury prevention. Feinting ability showed a 3.6 % decrease in reaction time (1.92s to 1.85s) with a moderate effect ($d = 0.68$, $t = 3.120$, $p = 0.005$) supported by narrow confidence intervals showing precise measurement. Finally, kicking power improved by 9.8 % (75.3 to 82.7 m/s) and was large, as indicated by the effect size ($d = 1.47$) and the excellent responsiveness (SRM = 1.32), while Wilcoxon Z = -4.12 ($p < 0.001$) confirmed almost no distributional overlap between pre- and post-testing sessions. In contrast, the control group showed no significant changes in any measure (all $p > 0.05$), with trivial to small effect sizes ($d = 0.08$-0.22), demonstrating the stability of testing procedures. Methodologically, all the analyses were normal (Shapiro-Wilk $p > 0.10$) and retained significance after Bonferroni correction ($\alpha = 0.0125$). Clinically, the Y-Balance improvements surpassed the minimal detectable change (MDC = 2.5 %), kicking velocity went above the 7.5 % meaningful change threshold, and feinting improvements surpassed the typical error of measurement (TEM = 0.04s); together, these indicate both statistical and practical significance of the intervention.

Table 2. Within-Group Pre-Post Comparisons

Variable	EG Pre	EG Post	t	p	d	CG Pre	CG Post	t	p
Y-Balance Right (%)	58.20 ± 7.90	60.80 ± 7.65	-8.105	<0.001*	1.77	59.50 ± 5.10	60.20 ± 5.15	-0.443	0.663
Y-Balance Left (%)	66.50 ± 9.85	69.10 ± 9.50	-9.345	<0.001*	1.95	67.80 ± 5.20	68.90 ± 5.00	-0.699	0.493
Feinting Ability (s)	1.92 ± 0.12	1.85 ± 0.10	3.12	0.005*	0.68	1.94 ± 0.80	1.91 ± 0.85	0.118	0.907
Kicking Power (m/s)	75.30 ± 6.95	82.70 ± 6.20	-6.725	<0.001*	1.47	73.80 ± 10.5	75.40 ± 9.85	-0.509	0.616

*(Paired t-tests with Cohen's d effect sizes)

Table 3. Between-Group Post-Intervention Comparisons

Variable	EG Post	CG Post	Mean Difference [95% CI]	t	p
Y-Balance Right (%)	60.80 ± 7.65	60.20 ± 5.15	0.6 [0.2, 1.0]	4.682	<0.001*
Y-Balance Left (%)	69.10 ± 9.50	68.90 ± 5.00	0.2 [0.1, 0.3]	4.793	<0.001*
Feinting Ability (s)	1.85 ± 0.10	1.91 ± 0.85	-0.06 [-0.10, -0.02]	2.803	0.005*
Kicking Power (m/s)	82.70 ± 6.20	75.40 ± 9.85	7.3 [5.8, 8.8]	3.921	<0.001*

*(Independent t-tests with 95 % CIs)

All performance measures showed statistically significant differences between the experimental (EG) and control groups (CG) postintervention. For kinetic stability, the EG showed better Y-Balance performances in both right (60.8 ± 7.65 % vs CG 60.2 ± 5.15 %; mean difference = 0.6 %, 95 % CI [0.2, 1.0], t = 4.682, $p < 0.001$) and left legs (69.1 ± 9.50 % vs 68.9 ± 5.00 %; mean difference = 0.2 %, 95 % CI [0.1, 0.3], t = 4.793, $p < 0.001$). The feinting ability analyses showed significantly faster reaction times in EG (1.85 ± 0.10 s vs CG 1.91 ± 0.85 s; mean difference = -0.06 s, 95 % CI [-0.10, -0.02], t = 2.803, p = 0.005). Most significantly kicking power had the largest difference between groups; EG had far higher ball velocities (82.7 ± 6.20 m/s vs CG 75.4 ± 9.85 m/s; mean difference = 7.3 m/s, 95 % CI [5.8, 8.8], t = 3.921, $p < 0.001$). These differences remained statistically significant even after Bonferroni correction of adjusted $\alpha = 0.0125$, with all confidence intervals excluding zero, thus indicating precise estimation of treatment effects. With large effect sizes (Cohen's d range: 0.89-1.42) and narrow confidence intervals, the isoinertia training intervention has been firmly established both statistically and scientifically.

Discussion

The present study presents strong evidence that 6 weeks of isoinertial eccentric training significantly impact performance measures in junior rugby players, such as kinetic stability, feinting ability, and kicking power. Thus, our findings broaden current views by demonstrating the capabilities of flywheel training in sport-specific skills in adolescent athletes, a demographic that previous eccentric training studies have largely neglected (Petré et al., 2018) (Bright et al., 2023).

The 4.5 % improvement observed in the right leg Y-Balance Test performance (d = 1.77) and the 3.9 % improvement in the left leg (d = 1.95) are well above the 2.5 % threshold for minimal detectable change set by (Schorderet et al., 2021). These improvements likely pertain to enhanced neuromuscular control and eccentric strength in the hamstrings and gluteal stabilizers, a finding consistent with results reported by (del Ama Espinosa et al., 2015) (Murton et al., 2021) examining basketball players. These improvements bilaterally imply that isoinertial training fosters symmetrical adaptations, reducing injury risk attributable to limb asymmetries (Mentele et al., 2022). Notably, our effect sizes exceed those reported in other studies using traditional resistance training (d = 0.8-1.2), substantiating that the flywheel-powered eccentric overload is more effective at improving dynamic stability.

An expectancy improvement in agility is the 3.6 % decrease in feinting reaction time (d = 0.68). Further, one can see that the testing conditions used for the evaluation were game-realistic using the Fitlight technology (Nikitenko, 2018). This finding is consistent with those who observed a similar effect on distance change (Zhang et al., 2010). The possible mechanism might be in the enhanced rate of force development (RFD) in the lower limbs to facilitate faster deceleration and reacceleration during direction changes, as cited by (Dos'Santos et al., 2018). The moderate effect size thus suggests that while agility can be improved through isoinertial training, such training should be complemented by sport-specific drills to achieve maximized conversion to complex game situations.

The most striking improvement was a 9.8 % increase in kicking velocity (d = 1.47), well above the 7.5 % difference required to be considered necessary in rugby performance (Zamparo et al., 2000). This backs up the work regarding soccer populations but extends it to rugby-specific kicking mechanics. The considerable effect size suggests that isoinertial training primarily benefits movements requiring explosive hip and knee extension. It combines both neural adaptation (increased motor unit synchronization) and morphological changes because of the increased fascicle length (Romero Boza et al., 2015). The standardized response mean (SRM = 1.32) proves excellent responsiveness to training, meaning that kicking power is one of the trainable attributes through this modality.

The stark contrast between groups (all between-group $p<0.005$) underscored the limitations of traditional rugby training for developing these specific capacities. During this period, control participants-maintained performance levels like baseline confirming test-retest reliability—with trivial gains (d = 0.08-0.22), thus putting forward eccentric overload training as a unique stimulus. In turn, this suggests an increase in evidence against the applicability of conventional resistance training for sports requiring rapid eccentric-to-concentric transitions (Hernández-Davó et al., 2021). This highlights the necessity for coaches and trainers to incorporate specialized training regimens that focus on these dynamic movements, ultimately optimizing athletic performance in sports like rugby, where explosive power is critical.

Conclusions

This study demonstrates that isoinertial eccentric training produces statistically significant and practically meaningful improvements in rugby-specific performance metrics. The large effect sizes across multiple domains support its incorporation into youth rugby conditioning programs, particularly for enhancing dynamic stability, agility, and kicking power. These findings advance our understanding of eccentric training applications in collision sports and provide evidence-based recommendations for athlete development.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Оцінка впливу ізоінерційного ексцентричного тренування на кінетичну стабільність, здатність до застосування фінтів та потужність ударів ногами у юних регбістів: Рандомізоване контрольоване дослідження

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 3 табл., 39 джерел.

Історія питання. Регбі потребує від гравців володіння вибуховою силою в нижній частині тіла, спритністю та стійкістю, причому ексцентричні рухи відіграють ключову роль у досягненні високих результатів і запобіганні травматизму. Хоча ізоінерційне тренування показало свою ефективність у підвищенні ексцентричної сили в інших видах спорту, його вплив на навички, необхідні для гри в регбі, залишається недостатньо вивченим.

Мета дослідження. Метою цього дослідження було вивчення впливу шеститижневої програми ізоінерційних силових тренувань на покращення показників кінетичної стабільності, здатності до застосування фінтів та потужності ударів ногами у юних регбістів.

Матеріали та методи. Сорок спортсменів чоловічої статі (вік: 15,2 ± 0,6 років) було рандомізовано на дві групи: експериментальну групу (n = 20), яка двічі на тиждень виконувала ізоінерційні тренування для зміцнення нижніх кінцівок, та контрольну групу (n = 20), яка продовжувала займатися традиційним тренуванням. Оцінювання показників на перед- і постінтервенційному етапах дослідження включало проведення тесту на рівновагу — Y-Balance (кінетична стабільність), тести на вміння застосовувати фінти із використанням системи тренувань “Fitlight” та вимірювання швидкості ударів ногами за допомогою радара.

Результати. Експериментальна група продемонструвала значне поліпшення показників щодо виконання тесту на рівновагу на правій нозі (+4,5 %, $p < 0{,}001$) і лівій нозі (+3,9 %, $p < 0{,}001$), швидший час реакції на застосування фінтів (−3,6 %, $p = 0{,}005$) та посилення потужності удару (+9,8 %, $p < 0{,}001$) порівняно з контрольною групою, в якій не спостерігалося суттєвих змін ($p > 0{,}05$).

Висновки. У дослідженні зроблено висновок, що проведення ізоінерційного ексцентричного тренування сприяє підвищенню показників результативності в регбі, ймовірно, завдяки поліпшенню нервово-м’язового контролю та ексцентричної сили. Отже, результати дослідження підтверджують доцільність включення ізоінерційного тренування в програми підготовки юних регбістів з метою покращення показників спритності, стійкості та потужності.

Ключові слова: ізоінерційне тренування, кінетична стабільність, швидкість удару ногою, спритність у застосуванні фінтів, реактивна сила, розвиток потужності.

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Cite this article as: Syed, A. A. S., Rajesh, W. R., Kalaivani, S., Purushothaman, R., Glady, K., & Glory, D. M. (2025). Assessing the Effects of Isoinertial Eccentric Training on Kinetic Stability, Feinting Ability, and Kicking Power in Youth Rugby Players: A Randomized Controlled Study. *Physical Education Theory and Methodology, 25*(4), 787-793. https://doi.org/10.17309/tmfv.2025.4.05

Received: 12.03.2025. Accepted: 02.06.2025. Published: 30.07.2025