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ORIGINAL ARTICLE

Bounce or step: The evolutionary leap in elite épée fencing footwork and its impact on performance

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ABSTRACT

This study investigates the evolution of footwork techniques in elite épée fencing, focusing on the traditional stepping method versus a modern bouncing technique. Using time-motion analysis of 163 bouts from the 2012 and 2020 Olympic Games, the research categorised footwork into two types: stepping (heel-to-toe) and bouncing (ball-of-foot, synchronous movement). Results revealed a significant shift in footwork preferences over time, with female fencers predominantly using bouncing footwork, which was significantly associated with higher attack success in both Olympic cycles. Male fencers, however, showed greater success with stepping footwork. Statistical analysis confirmed moderate to weak associations between footwork type and attack success, with 66.7% of Olympic medallists using bouncing footwork, though gold medals were more often won with stepping. The findings suggest that while both footwork styles can be effective, their success may depend on sex, tactical preference, and possibly national coaching strategies. This is the first empirical study to directly compare these footwork styles in fencing, highlighting the need for further biomechanical research and supporting a more individualised approach to athlete development.
Keywords: Performance analysis, Biomechanics, Time-motion analysis, Combat sports, Tactical performance, Olympic fencing, Movement efficiency.

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INTRODUCTION

Fencing, with its origins in warfare and duelling, has evolved into a modern Olympic sport while retaining many traditional elements (Cohen, 2002). One such tradition is the coaching methodology that emphasises a heel-to-toe stepping footwork pattern. This technique involves advancing and retreating by initiating contact with the heel—a method historically suited to uneven combat terrain (Evangelista, 1996; Gaugler & Nadi, 1997). Despite the modern fencing piste offering a uniform surface, this traditional footwork style remains prevalent in coaching and competition.

As in all high-performance sports, athletes and coaches continually seek movement adaptations that confer a competitive edge. Harmenberg, Väggö, and Schmitt (2015) observed that contemporary elite épée fencing demands faster movements, shorter engagement distances, and more efficient weapon handling. In response, Turner and Harmenberg (2018) proposed an alternative footwork style—bouncing—characterised by synchronous leg movement and propulsion from the balls of the feet. This technique may leverage the stretch-shortening cycle of the Achilles tendon, potentially enhancing speed and energy efficiency (Caron, Burr, & Power, 2020; Filipas et al., 2023), a mechanism well-documented in sports biomechanics (Komi, 2000). Although bouncing footwork is well-documented in other combat sports such as taekwondo, kickboxing, and karate—where it supports rapid, forceful movements and reactive agility (Lee & Song, 2020; Margaritopoulos et al., 2015; Uthoff et al., 2023)—its role in fencing remains underexplored. These sports demonstrate how bouncing footwork can facilitate quicker directional changes and explosive actions, which are also critical in fencing (Lee, Jonghwa & Park, 2022).

While previous studies have addressed physiological, biomechanical, and injury-related aspects of fencing (Dedieu et al., 2024; Oates et al., 2019; Swatowska, Akbas, & Juras, 2020; Tataran et al., 2023; Thompson et al., 2022), few have directly examined footwork styles and their impact on performance outcomes. Bottoms, Greenhalgh, and Sinclair (2013) and Turner et al. (2014) have acknowledged the importance of footwork, but without empirical comparison of distinct styles.

Despite the centrality of footwork to fencing performance, there is a notable absence of empirical research directly comparing the effectiveness of different footwork styles in elite competition. Understanding these differences is crucial for optimising training strategies and enhancing competitive outcomes. This investigation contributes to the broader field of sports biomechanics by examining how movement strategies evolve in response to performance demands and how these adaptations influence success at the highest level.

Using a time-motion analysis of Olympic competition footage, this study systematically categorises footwork styles and evaluates their association with attack success. The research aims to determine whether the bouncing technique offers a performance advantage over the traditional stepping method. Findings may inform coaching practices by identifying which footwork styles are most effective under elite competitive conditions, thereby supporting evidence-based athlete development.

MATERIALS AND METHODS

Experimental approach to the problem

Using an observational study design, this research identified differences in footwork techniques and how they affected performance in men's and women's épée fencing during the 2012 and 2020 Olympic Games. The study analysed publicly available video footage of Olympic level fencing matches.

Participants

A total of 163 bouts were analysed from 53 elite men's and 44 elite women's epée fencers from 21 National Federations during two Olympic games (2012 & 2020), which represented all accessible publicly available video recorded data at each time point. No individual identifiable information is used within the published data. The study was conducted according to the Declaration of Helsinki, and the protocol was approved by Middlesex University, London Sport Institute Ethics Sub-Committee for use of open-access video footage prior to analysis commencing.

Procedures

Bout analysis

Each male and female team and individual competition Poule and knock-out rounds were analysed from the first available complete record of Olympic epée fencing bouts (2012), versus the 2020 Olympic games. Due to the volume of data, two coders with experience coding fencing, coded the bouts. Because of the scheduling of Olympic fencing, which changes with each Olympic cycle (for instance, not enough competitors to make a full 'team' competition), it was necessary to use all bouts available from each competition, hence the combination of both individual and team bouts.

Movement classification

Assessment firstly distinguished between two primary footwork styles, which then informed the categorisation of subsequent movements. The first style, Type 1, is characterised by a traditional heel-to-toe motion (stepping/heel-to-toe), while the second style, Type 2, features a modern bouncing technique (bouncing). Both styles were defined according to the classification by Turner & Harmenberg (2017). Subsequently, each fencer's performance was evaluated based on the frequency and effectiveness of their attacks, culminating in a compiled overview of outcomes associated with each footwork type. Detailed descriptions of the movement classifications, attack categories, and their definitions are provided in Table 1 for reference. An athlete/team were classified by their footwork type if they completed over 85% of their attacks in a single footwork style.

Table 1. Movement classifications and operational definitions.

Classification	**Definition**
Stepping footwork	From the 'on-guard' position, the fencer advances by lifting the toe of the leading foot stepping forward, landing on the heel and placing the foot flat. The rear foot is then picked up and moves an equal distance forward, landing on the mid-foot. The retreat is the reverse action with the front foot pushing off with the heel. The distance between the feet shortens and lengthen with each step. Importantly, the feet move independently.
Bouncing footwork	From the 'on-guard' position, the fencer is positioned with their weight loaded over the balls of their feet, with their heels not in contact with the piste. Advancement and retreat are made by the fencer bouncing along the piste, limiting heel contact with the surface. A pushing action with the ball of the foot is used to either advance or retreat. The distance between the feet rarely change, as the feet both move concurrently.
Attack success	An attack is deemed successful if a point is registered.
Number of attacks	Measured by the number of times an attack is initiated by each fencer throughout the bout.

Video analysis system

To capture the movement classifications, a video-analysis system was created using SportsCode™ Elite (Sportstec™ Limited, Warriewood, Australia). A Code-Window was created with code buttons assigned to each athlete, and the success of their attack. Label buttons describing the footwork type (Bouncing footwork or Stepping footwork) were created and then assigned to each athlete, alongside a label button to note which bout the athletes were in. During each bout, the independent analyst first coded for the attacking success (successful or unsuccessful attack) for the related athlete. Once the suitable code button was selected and coded, the analyst then selected and coded for the corresponding footwork type of the athlete, and the specific bout. After each bout and code sequence, the analyst edited the 'Bout' button to denote the correct bout.

This system was used to code attacking success of each athlete and the footwork using a lapsed-time analysis system, meaning all analysis was completed 'post-fight', not 'real-time'. Hotkeys were assigned to each code and label button, so that information can be coded without the need to have the Code-Window interface open on screen. Once each bout was coded, the Matrix from SportsCode™ Elite was analysed, and the coded events in the timeline were exported as a CSV. File from SportsCode™ Elite into Microsoft Excel (Microsoft Corp, Redmond, Washington, USA). The frequency of attacking successes and footwork types during each fighting bout of the data sample were calculated.

Analysis

Statistical analyses were carried out using SPSS statistical software package (Version 28; SPSS Inc., IL, USA). To determine inter-rater agreement, Cohen's kappa (κ) statistic was used (Cohen, 1960). As suggested by Viera and Garrett (2003), kappa values <0.21-0.40, 0.41-0.60, 0.61-0.80, 0.81-100 indicating trivial, fair, moderate, substantial and almost perfect agreement, respectively. Each coder independently analysed a minimum of 10% of the total number of bouts.

To account for unequal sample sizes between sex and participants at each Olympic games, a chi-square (χ^2) test of independence was performed to examine the following relationships: sex and footwork type; attacking success and footwork type between Olympic games and sex; success of bouncing footwork attack between Olympic games and sex; success of stepping footwork attack between Olympic games and sex; and finally analysis of medal results for footwork type.

Differences between the two footwork types and attack success were analysed using magnitude-based Cramer's V (1946) effect size (ES). Description for magnitude of association is described as according to Rea & Parker (1992): <0.10 = negligible, 0.10 and under 0.20 = weak, 0.20 and under 0.40 = moderate, 0.40 and under 0.60 = relatively strong, 0.60 and under 0.80 strong, 0.80 to 1.00 = very strong association. Ninety per cent confidence limits (+90% CL) were calculated to indicate the precision of the estimate of observed effects.

RESULTS

Degree of inter-rater agreement

Cohen's κ was run to determine the level of inter-rater reliability between the two coders, using 10% of the total number of bouts coded. This resulted in 457 attacks being used for reliability. There was almost perfect agreement found between the two coders, κ = 0.892 (95% CI, 0.46,1.32), $p < .001$.

Chi-square associations

Chi-square (χ^2) showed three significant associations. Firstly, the relationship between footwork type and sex in 2012 versus 2020 were significant. Male (Stepping footwork): $\chi^2(1, N = 1744) = 82.776$, $p \leq .001$, ES = -0.218 (moderate) and female (Bouncing footwork): $\chi^2(1, N = 1320) = 36.201$, $p \leq .001$, ES = 0.166 (weak); see Figures 1 and 2 showing successful (S) and unsuccessful (U) attacks. Males were more likely to use stepping attacks in 2012 (80%) & 2020 (58%), whereas females were more likely to use bouncing attacks in 2012 (73%) & 2020 (57%).

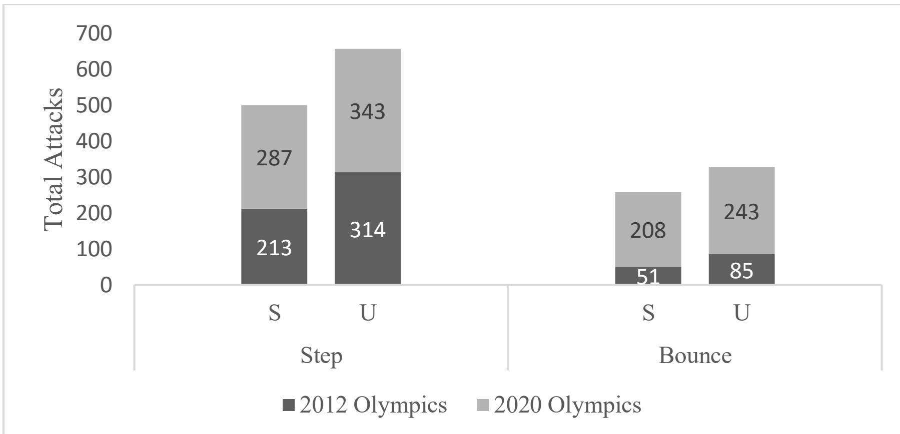

Figure 1. Success of stepping and bouncing attacks 2012 versus 2020, male.

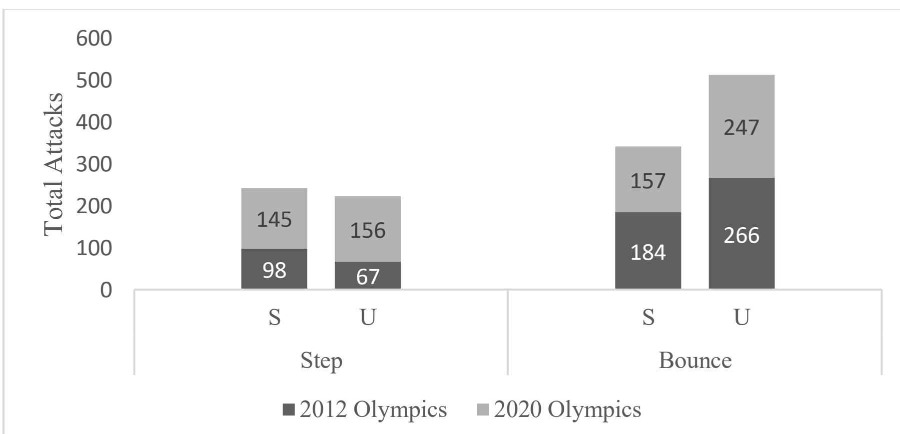

Figure 2. Success of stepping and bouncing attacks 2012 versus 2020, female.

The relationship between footwork type and attack success for females in both 2012 and 2020 competitions was significant. 2012: $\chi^2(1, N = 615) = 16.652$, $p \leq .001$, ES = -0.165 (weak). 2020: $\chi^2(1, N = 705) = 6.107$, $p \leq .001$), ES = -0.093 (negligible). Greater attack success was seen with bouncing vs stepping footwork in 2012 (65.2%) and 2020 (52.0%) respectively. See Figure 2. Females maintained a significant association between bouncing footwork attacks from 2012 to 2020; $\chi^2(1, N = 854) = 0.365$, $p = .546$, ES = -0.021 (negligible). Success of bouncing footwork style has not changed between Olympic games.

Analysis of medal results from 2012 & 2020 Olympics are shown in Table 2. With the medallists referenced in relation to stepping and bouncing footwork.

Table 2. Medal count of stepping and bouncing for male and female athletes at 2012 & 2020 Olympic Games.

2012 Olympics results (Individual Events)	**2020 Olympic results (Team events)**
Gold – Stepping (male) Bouncing (female)	Gold – Stepping (male) Stepping (female)
Silver – Bouncing (male) Bouncing (female)	Silver – Bouncing (male) Bouncing (female)
Bronze – Stepping (male) Bouncing (female)	Bronze – Bouncing (male) Bouncing (female)
66.7% of medallists bounce, 50% of gold medallist's step.	66.7% of medallists bounce, 100% gold medallist's step.

DISCUSSION

This study aimed to investigate the prevalence and effectiveness of two distinct footwork styles—traditional stepping and modern bouncing—used by elite épée fencers during the 2012 and 2020 Olympic Games. The findings confirmed the presence of both styles across male and female competitors, with notable differences in usage patterns and performance outcomes between sexes and across time.

Female fencers predominantly used bouncing footwork in both Olympic cycles (73% in 2012 and 57% in 2020), and this style was significantly associated with higher attack success rates (65.2% in 2012 and 52.0% in 2020), as shown in Figure 2. In contrast, male fencers favoured stepping footwork (80% in 2012 and 58% in 2020), which was also associated with higher success rates (Figure 1). These findings partially support the hypothesis that bouncing footwork may offer a performance advantage, particularly among female athletes.

Interestingly, while 66.7% of all medallists across both Games used bouncing footwork, gold medals were more frequently won by athletes employing the traditional stepping style—50% in 2012 and 100% in 2020 (Table 2). This suggests that although bouncing footwork is increasingly prevalent and may offer tactical benefits, stepping remains a highly effective and possibly more stable technique at the highest level of competition. Coaches should therefore consider both styles as viable options, with selection tailored to individual athlete characteristics and tactical preferences.

The shift toward a more balanced use of both footwork styles from 2012 to 2020 (Figures 1 and 2) indicates an evolution in fencing strategy, potentially influenced by changes in coaching philosophy, athlete development, or the physical demands of modern épée fencing. The increased adoption of bouncing footwork may reflect its advantages in speed, energy efficiency, and responsiveness—qualities also valued in other combat sports such as taekwondo and kickboxing, where bouncing is used to facilitate rapid directional changes and explosive movements (Lee & Song, 2020; Uthoff et al., 2023).

Despite these trends, the data also suggest that stepping footwork may yield higher precision or efficiency per attack, particularly among male fencers. Post hoc analysis showed that while bouncing footwork was used more frequently, stepping footwork had slightly higher success rates in some contexts (e.g., 46% success for stepping vs. 39% for bouncing among females in 2020). This could imply that while bouncing allows for greater volume of attacks, stepping may be more effective in terms of accuracy or timing. Such distinctions highlight the importance of context-specific application of footwork styles, depending on the athlete's physical attributes, tactical approach, and bout dynamics.

The findings also raise questions about the influence of national coaching systems, as anecdotal observations suggest that footwork preferences may align with country-specific training methodologies. This warrants further investigation into how cultural and institutional factors shape technical development in fencing.

The increased use of bouncing footwork from 2012 to 2020, particularly among female fencers, may reflect broader trends in combat sports where agility and rapid directional changes are prioritised. These parallels suggest that fencing may be undergoing a biomechanical evolution, driven by the demands of faster-paced, shorter-distance exchanges (Harmenberg et al., 2015). However, the continued success of stepping footwork—especially among gold medallists—indicates that tradition and innovation may coexist as complementary strategies in elite fencing.

This study is limited by its reliance on publicly available video footage, which restricted access to individual anthropometric data and in-bout contextual variables. The observational design also precludes causal inference regarding the biomechanical advantages of each footwork style. Additionally, the classification of footwork was based on visual coding, which, while reliable ($\kappa = 0.892$), may not capture subtle biomechanical nuances.

Future research should incorporate motion capture, force plate analysis, and electromyography to explore the underlying mechanics of each technique, including ground contact time, energy expenditure, and neuromuscular activation patterns. Investigating the influence of national coaching systems and cultural factors on footwork preferences would also provide valuable insights. Expanding the dataset to include World Cup competitions could offer a broader view of elite-level trends, given the greater international representation and diversity of styles.

Moreover, future studies should consider the role of athlete morphology—such as height, limb length, and body mass—in footwork preference and effectiveness. It is plausible that taller or heavier athletes may favour stepping due to greater tendon loading, while lighter athletes may benefit more from the agility afforded by bouncing footwork.

CONCLUSION

This study provides the first empirical comparison of stepping and bouncing footwork styles in Olympic épée fencing. The results demonstrate that both styles are used effectively at the elite level, with sex-specific trends and evolving usage patterns over time. Bouncing footwork was associated with greater attack success among female fencers, while stepping remained more effective for male fencers and more common among gold medallists.

These findings underscore the importance of an individualised approach to footwork training, where athletes are equipped to utilise both styles depending on tactical demands and personal strengths. The study contributes to the broader field of sports biomechanics by highlighting how movement strategies in fencing are adapting to the evolving demands of elite competition.

Incorporating additional footwork techniques can provide tactical advantages in competition. Coaches (both technical and physical) should be aware of the differences in these movement patterns and prepare their athletes to be able to utilise both, adding to their athlete's skillsets. However, as this research has identified success is possible through both footwork styles, an individualised approach is needed.

AUTHOR CONTRIBUTIONS

Jon A. Cree led the study conception and design, carried out the material preparation and data collection, performed the data analysis, and wrote the first draft of the manuscript. Luke W. Oates and Anthony N. Turner provided supervision and critical guidance throughout the project. All authors commented on and revised previous versions of the manuscript, and all approved the final version.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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