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COMPARATIVE ANALYSIS OF UNIPEDAL BALANCE PARAMETERS IN YOUNG FENCERS

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Abstract: *The study evaluated unipedal balance in 12–14-year-old fencers from Quatro Bucharest using a Sensamove MiniBoard (10 s test, 10° tilt). Average performance was 72.43% on the right leg (RL) and 71.14% on the left (LL). Mean deviations were RL: 1.88° front, –2.01° back; LL: 1.92° front, –1.98° back. LL showed higher coefficient of variation and more asymmetric distributions, especially in back deviation, indicating less consistent control. Performance stability was similar, though deviation rose slightly from RL (7.23%) to LL (8.26%). A significant difference appeared in left deviation (p = 0.045), with RL more stable, suggesting the need for targeted left-leg training.*

Key words: *unipedal balance, postural stability, performance, deviations, comparative analysis.*

1. Introduction

Balance is highly important in fencing, a sport characterized by rapid directional changes, explosive movements and precise footwork [4], [19], [23]. The ability to maintain postural stability, particularly in unipedal stances, is essential for fencers to execute attacks and defensive maneuvers successfully [14], [17], [26]. Given the asymmetrical nature of fencing, where athletes predominantly rely on one leg for support during lunges and weight shifts, understanding unipedal balance parameters is of paramount importance in both performance optimization and injury prevention [3], [25].

Previous research highlights the significance of balance and postural control in elite fencers, showing that dynamic balance is well-developed and comparable between lower limbs [1]. However, studies also suggest that specific training interventions can influence balance and reaction time in fencers [5], and that balance abilities may vary depending on experience level [21]. Additionally, biomechanical analyses of movements such as the fleche landing indicate the potential risk of ankle injuries, further underscoring the need for stability training [9].

This study is to provide a comparative analysis of unipedal balance parameters in young fencers, investigating differences between dominant and non-dominant

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limb and exploring how training influences balance development [1], [13], [16]. By integrating findings from prior research on balance assessment methods [27] and sensory integration in sports [10], this study seeks to contribute to a deeper understanding of the role of unipedal stability in fencing performance. Findings will also be compared with balance characteristics observed in other sports, such as ten-pin bowling [24], to provide a broader perspective on the requirements of fencing-specific balance.

Understanding unipedal balance in young fencers is closely related to biomechanics. Thus, the rapid directional changes and asymmetrical footwork in this sport entail high mechanical demands on the lower limbs that directly influence postural control and technical execution [20].

This research analyzes side-to-side differences in unipedal postural control among young fencers, focusing on dominant versus non-dominant limb stability. Previous studies pointed out that inter-limb asymmetries can increase non-contact lower-limb injury risk in youth athletes [13], although elite fencers maintain high postural stability despite the sport's inherent asymmetry [6]. Furthermore, bilateral asymmetries in young elite fencers may influence both performance and injury prevention strategies [7].

By joining quantitative balance assessments with evidence from sensory integration and fencing biomechanics, this study underscores how sport-specific demands shape lower-limb balance. This is in line with previous research revealing that fencing necessitates precise lower-limb coordination and rapid postural adjustments [4]. This is in line with previous research revealing that fencing necessitates precise lower-limb coordination and rapid postural adjustments [4]. Fencing relies on early and anticipatory control mechanisms meant to stabilize explosive lunges [2]. Despite the asymmetric stance of the fencer, a comparable dynamic balance of the limbs is obtained through targeted training adaptations [1].

The results provide practical guidance for coaches and trainers in designing targeted exercises that enhance stability and reduce injury risk in developing athletes. This is consistent with evidence showing that integrative neuromuscular training improves sensorimotor control and mitigates lower-limb injury risks in young athletes [11]. Structured core-stability training programs support trunk control and functional movement patterns that are essential for injury prevention [15]. The multiple-component prevention strategies incorporating strength, balance and agility training effectively reduce injury incidence while fostering long-term sports development [22].

The aim of this study is to conduct a comparative analysis of unipedal balance parameters in young fencers, examining potential asymmetries between the dominant and non-dominant leg and evaluating how fencing training influences postural stability for performance improvement and injury prevention.

2. Methods

The study aimed to assess unipedal balance in young fencers aged 12 to 14 years.

In this regard, a cross-sectional study was organized at the Quatro Bucharest Fencing Club, scheduled for May 2024. To assess unipedal balance, the Sensamove

MiniBoard platform was used. The measured parameters included performance and average deviation in the front, back, left and right positions, with a testing duration of 10 seconds and a maximum tilt angle of 10 degrees.

Statistical analysis was performed using KyPlot software, applying descriptive and comparative indices and a t-Test Paired Comparison for Means. The data were reported with a significance threshold of $p<0.05$.

3. Results

The following table 1 and Figure 1 presents descriptive and comparative analysis of unipedal balance indices for both the right leg (RL) and left leg (LL) in young fencers.

Descriptive and comparative analysis of the unipedal balance indices Table 1

Statistical indicators	Perf. (%)		Front, avg. dev. (degree)		Back, avg. dev. (degree)		Left, avg. dev. (degree)		Right, avg. dev. (degree)	
	RL	**LL**	**RL**	**LL**	**RL**	**LL**	**RL**	**LL**	**RL**	**LL**
mean	72.43	71.14	1.88	1.92	-2.01	-1.98	-1.07	-1.66	1.35	0.94
Cv(%)	11.93	14.49	50.69	55.36	53.21	45.28	36.99	47.36	45.98	47.29
Skewness	-0.64	-1.36	-0.20	0.94	-0.60	-1.28	-0.37	-0.81	-0.11	0.07
Kurtosis	-0.21	1.37	-1.28	-0.58	1.05	1.88	-1.08	-0.05	-0.92	0.43
Mean Dev.	7.23	8.26	0.82	0.91	0.81	0.70	0.34	0.59	0.54	0.33
CLM(0.95)	4.99	5.95	0.55	0.61	0.62	0.52	0.23	0.45	0.36	0.26
Quartile Range	10.5	12.0	1.78	1.21	0.98	0.95	0.61	0.41	0.79	0.27
t	0.35		0.13		0.06		2.22		2.08	
P	0.729		0.895		0.954		0.045*		0.057	

Notes:

Perf. – performance, dev.- deviation, RL – right leg, LL – left leg; Confidence Level of Mean (0.95); t-Test Paired Comparison for Means

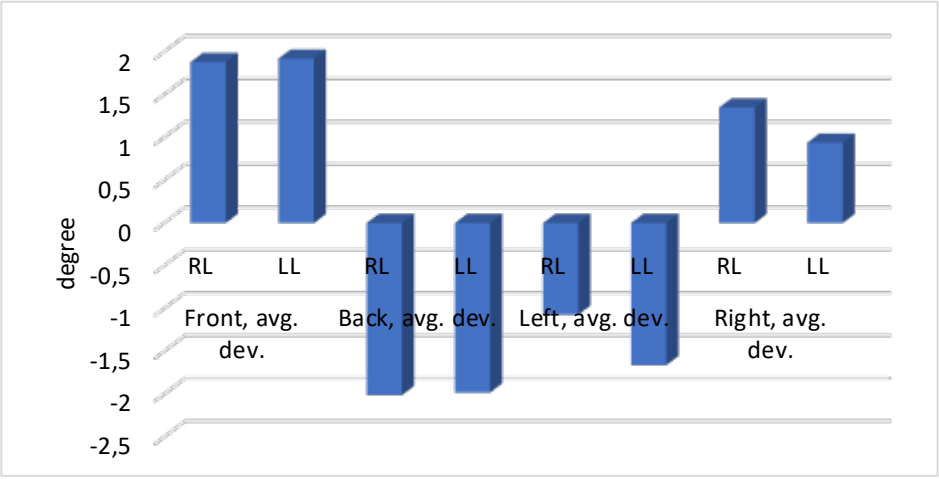

Fig. 1. *Comparative average deviation of the unipedal balance*

The average postural balance performance was 72.43% for the right leg (RL) and 71.14% for the left leg (LL), indicating a slight difference between the two legs. The average deviation for RL was 1.88° (front) and -2.01° (back), while for LL, the deviations were 1.92° and -1.98°, respectively. The coefficient of variation (CV%) was higher for LL, indicating greater variability in balance control. The values for asymmetry and kurtosis showed an asymmetric distribution, more pronounced for the left leg in back deviation, suggesting less consistent performance. Performance stability was relatively constant, with a slight increase in the average deviation from RL (7.23%) to LL (8.26%). The 95% confidence intervals indicated reliable measurements for both feet. Statistical comparison revealed a significant difference in performance for left deviation ($p = 0.045$), with RL exhibiting better stability. No significant differences were found in the other comparisons.

4. Discussion

The analysis of unipedal balance in young fencers is essential for understanding how they control posture and distribute weight during sport-specific movements [6], [27]. This study investigated the differences in postural balance between the right and left leg, revealing possible asymmetries and variability in stability control.

The results indicate a slightly higher postural performance for the right leg (72.43%) compared to the left leg (71.14%), suggesting a slight preference or dominance in maintaining balance. This difference is also supported by the coefficient of variation (CV%), which was higher for the left leg, revealing an increased variability in postural control on this side. These findings align with previous research highlighting that footedness is influenced by both stability and manipulation factors, affecting balance performance and control variability [12]. Recent studies on elite fencers have focused on the impact of fencing-specific demands on postural stability, emphasizing asymmetries in balance control due to sport-related adaptations [6].

The average forward and backward deviation was similar between the two feet; however, the analysis of asymmetry and kurtosis values showed a less uniform distribution for the left leg, particularly in backward deviation. This finding reveals greater instability on this side, possibly due to biomechanical characteristics or more frequent use of the right leg in fencing-specific technical executions. Previous research has pointed out the special biomechanical requirements of fencing, namely rapid directional changes and precise footwork, potentially leading to asymmetries in postural control [4]. Additionally, studies on fencing-specific training emphasize the importance of tailoring exercise prescriptions to address these biomechanical challenges, especially in improving balance and stability under sport-specific conditions [25]. Kinematic analyses of fencing footwork further indicate that movement patterns and stopping mechanics contribute to asymmetries, influencing stability and balance performance over time [18].

The statistical analysis pointed out a significant difference in balance performance for leftward deviation ($p = 0.045$), with the right foot showing greater stability. This signifies a potential lateral

asymmetry in postural control, which may be influenced by biomechanical or sport-specific factors. Previous research has highlighted that fencing-specific movements can lead to postural adaptations. Elite fencers often display balance asymmetries due to the unilateral nature of their sport [6]. However, studies on dynamic balance in fencers prove that lower extremities tend to have relatively similar balance capacities, despite minor deviations in specific directions [1]. Additionally, research on asymmetry in fencers has demonstrated that differences in strength and stability may arise from the dominant use of one side, reinforcing the need for training interventions that address these imbalances [8]. Nevertheless, the absence of significant differences in other comparisons indicates a generally balanced control between the two lower limbs, suggesting that young fencers develop a relatively symmetrical postural stability despite minor variations in specific movement directions.

These findings may have practical implications for the training of young fencers, revealing the need for specific exercises to improve stability of the left leg, particularly in maintaining backward postural balance. Moreover, monitoring and adjusting training programs meant to reduce postural asymmetries could contribute to optimizing performance and preventing injuries.

These results complement the existing specialized literature by underlining the adaptive nature of postural control in sports that require rapid, multidirectional actions. Studies in youth athletes show that early implementation of neuromuscular and proprioceptive training enhances inter-limb coordination and limits the development of chronic asymmetries, particularly when combined with progressive strength work for the lower limbs.

Information on balance-oriented interventions in combat and racket sports further demonstrates that sensorimotor drills integrated into regular practice can reduce side-to-side variability and improve reaction efficiency under competitive conditions. For fencing specifically, recent biomechanical research suggests that incorporating unilateral stance tasks, dynamic perturbation exercises and core-stability elements may better replicate the demands of bout situations and support symmetrical balance development. So, individualized monitoring of balance parameters over successive training cycles could serve as both a performance marker and an injury-prevention strategy for adolescent fencers.

These aspects also underscore the importance of including progressive proprioceptive and neuromuscular training into regular fencing practice. Targeted one-leg balance drills on unstable surfaces, combined with perturbation exercises, can enhance sensorimotor control and reduce side-to-side discrepancies [11]. Moreover, strengthening the core and posterior chain musculature has been shown to improve trunk stability and support lower-limb alignment, thereby decreasing the likelihood of overuse injuries [15]. Consistent evaluation of inter-limb asymmetry through scheduled balance testing allows coaches to detect deficits at an early stage and adjust training loads accordingly, a practice recommended in comprehensive youth injury-prevention programs [22]. In parallel, recent paper by Pavel et al. (2023) points out that integrating biomechanical assessment into

the technical training of junior fencers enables more accurate refinement of movement patterns, thereby improving postural control and overall performance quality [20]. Using balance-oriented elements within fencing specific footwork—such as dynamic lunges, fleche landings and rapid directional shifts—can help transfer stability improvement to real-match situations while lowering the risk of injury at the same time.

Based on the present findings and supporting literature, several practical strategies can strengthen training programs for young fencers:

1. *Progressive proprioceptive and neuromuscular drills* – Balance training on unstable platforms (for example, wobble boards, BOSU) combined with eyes-closed exercises or unexpected perturbations reduce asymmetries and improve rapid postural responses in young athletes.
2. *Core and posterior chain strengthening* – Including trunk-stability exercises and targeted glute–hamstring workout helps maintain proper lower-limb alignment and lowers the risk of overuse injuries common in unilateral sports.
3. *Regular and individualized monitoring* – Periodic balance testing at the beginning and the end of each training cycle can serve as both a performance metric and an early-warning system for occurring problems of the lower limbs, allowing timely adjustment of training loads.
4. *Sport-specific integration* – Unipedal tasks and perturbation drills should be embedded directly into fencing movements (lunges, fleche landings, rapid directional stops) to ensure that stability gains transfer effectively to competitive conditions.

These recommendations are consistent with recent findings highlighting that early implementation of neuromuscular training in multidirectional or combat sports contributes to symmetrical development, enhances sensorimotor control and reduces injury risk, thereby supporting both long-term sports performance and athlete safety.

5. Conclusion

The study highlights that, in the case of the young fencers, there is a slight dominance of the right leg in postural control. This fact reflects a lateral asymmetry in balance performance, with implications for sport-specific adaptations.

Significant variability in balance control was observed on the left leg, emphasizing the need for targeted training to address these imbalances and improve general postural stability.

Despite minor deviations, the overall balance between the two lower limbs appears relatively symmetrical, indicating that young fencers develop balanced postural control despite small differences in specific movement directions.

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