EFFECTIVE TRAINING INTERVENTIONS FOR THE DEVELOPMENT OF SPEED IN FENCING: A SYSTEMATIC REVIEW

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https://doi.org/10.35189/dpeskj.2021.60.4.9

Abstract. *Fencing is a sport in which speed, agility, explosive power and anaerobic endurance are essential for performance; reaction speed and the accuracy of the hit are also indispensable for achieving an optimal technique. This study aimed to analyse the scientific literature in order to find the most effective training methods for the development of speed in fencing. Google Scholar, PubMed and Web of Science databases were accessed with the purpose of finding original research studies focused on developing different forms of speed in fencing for any technical element of this sport, which were written in English, Romanian or Hungarian and were accessible in full text. Finally, 16 articles were included in the study. The types of training that led to improved fencing speed were: eccentric and plyometric training, strength training, core strength training, speed training, agility training, instability resistance training, fitness training, circuit training, ballistic and dynamic stretch training (during warm-up), functional training, bilateral transfer training, SAQ (speed, agility, quickness) training. These types of training were applied to foil, sabre and épée fencers of both genders, from various age groups and with different levels of training over periods between 1 and 12 months. To date, the exclusive superiority of one method has not been explicitly proven. In conclusion, it can be argued that several types of training can develop different forms of fencing speed, especially reaction and execution speed, which helps to achieve better performance in this sport.*

Keywords: *fencing, speed, reaction speed, execution speed.*

Introduction

Fencing is an opened-skill sport in which the fight takes place between two duelling athletes who use one of the three weapons: épée, foil or sabre (Chtara et al., 2020). In épée and foil, a touch is performed by thrusting, while in sabre, this is done with the edge of the blade (Aquili et al., 2013). In fencing, a thrust or cutting edge is called a touch line. Although the technical and tactical requirements are very different for these three weapons, it is however necessary for all fencers using all weapons "to lunge, change direction, and recover to *en garde* as soon as possible" (Turner et al., 2017, p. 1666).

Fencing involves a series of explosive attacks followed by low-intensity movements, predominantly entailing anaerobic metabolism (Wylde et al., 2013).

During competitions, fencers must maintain defensive and offensive movements and therefore it is very important for their motor skills to be highly developed. Specific movements, for instance stepping back and forward or jumping, which are used "to make a *touché* to the opponent are directly proportional to the athlete's agility and muscle strength. In general, these performance parameters may vary depending on the body size and structure of the fencers, but they can compete with equal success" (Turna, 2020, p. 127)

Sorel et al. (2019) highlight the importance of high levels of coordination, explosive power, speed and accuracy for fencing effectiveness. These are associated with "perceptual and psychomotor skills (i.e., the ability to quickly and appropriately respond to an opponent's actions)" (Turner et al., 2014, p. 3001).

Due to the training process and characteristic movements during an assault, fencing can be considered a sport in which reaction time plays a significant role in achieving sports performance (Czajkowski, 2005). Speed is classically defined as the shortest time needed by an object to move along a fixed distance. In fencing, speed is defined as an athlete's ability to perform and complete a movement in the shortest possible time, and reaction speed is one of its decisive components. Quick reaction, which is closely related to the processing of visual or tactile stimuli, muscle coordination during the movement, technical and tactical skills or optimal mental state, greatly influences the overall fencing performance (Balkó et al., 2016). To be successful in attack, the fencer needs to react as fast as possible to the opponent's actions (Milic, Janicijevic et al., 2020). Roi and Bianchedi (2008) suggest that, after identifying relevant information from the opponent, it is important for the fencer to react quickly, which requires "good coordination to achieve both speed and accuracy" (p. 474).

The lunge is the most commonly used form of fencing attack and its speed "is considered critical to success" (Guan et al., 2018, p. 201). In order to lunge, the fencer advances from the *en-garde* position, exerts force with the rear foot, accelerating forward with a thrust of the weapon arm and a step with the front foot (Stewart & Kopetka, 2005). "This acceleration phase ends when the rear foot stops to push against the floor" (Gutierrez-Davila et al., 2013, p. 364). Because fencers are constantly under time pressure, they are forced to reduce their decision-making time and sensorimotor response time (Milic, Nedeljkovic et al., 2020).

Among all the forms of speed encountered in fencing (reaction, execution, repetition, movement, uniform or non-uniform speed), it can be said that reaction speed and execution speed are preponderantly the subject of published research. In the literature, there is a wide range of studies on reaction speed in fencing but none confirms that a certain type of training programme is the most effective (Torun et al., 2012).

This study aimed to analyse the scientific literature in order to find the most effective training interventions for the development of speed in fencing athletes.

Methodology

A systematic search of the literature was performed in Google Scholar, PubMed and Web of Science databases. The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) methodology was respected by establishing some inclusion and exclusion criteria for the identified scientific materials (Page et al., 2021). The search was not limited to a certain period of time; the initial search revealed articles published between 1968 and 2021. The following keyword associations were used to search for information: "fencing", "fencing speed", "reaction speed in fencing" or "reaction velocity in fencing", "fencing speed development", "training"; connectors such as "and" or "or" were also used.

This study included articles that focused on the development of fencing speed (for any technical element), which were written in English, Romanian or Hungarian and were accessible in full text. After the initial search, duplicates were removed, and the remaining articles were evaluated in detail. Systematic reviews, meta-analyses and single-participant articles were excluded, as well as those that were not explicitly related to our study.

Results

The preliminary search led to the identification of 79 articles, of which 16 articles with original studies were considered eligible and included in the final analysis that made concrete references to the methods approached to increase fencing speed (Figure 1).

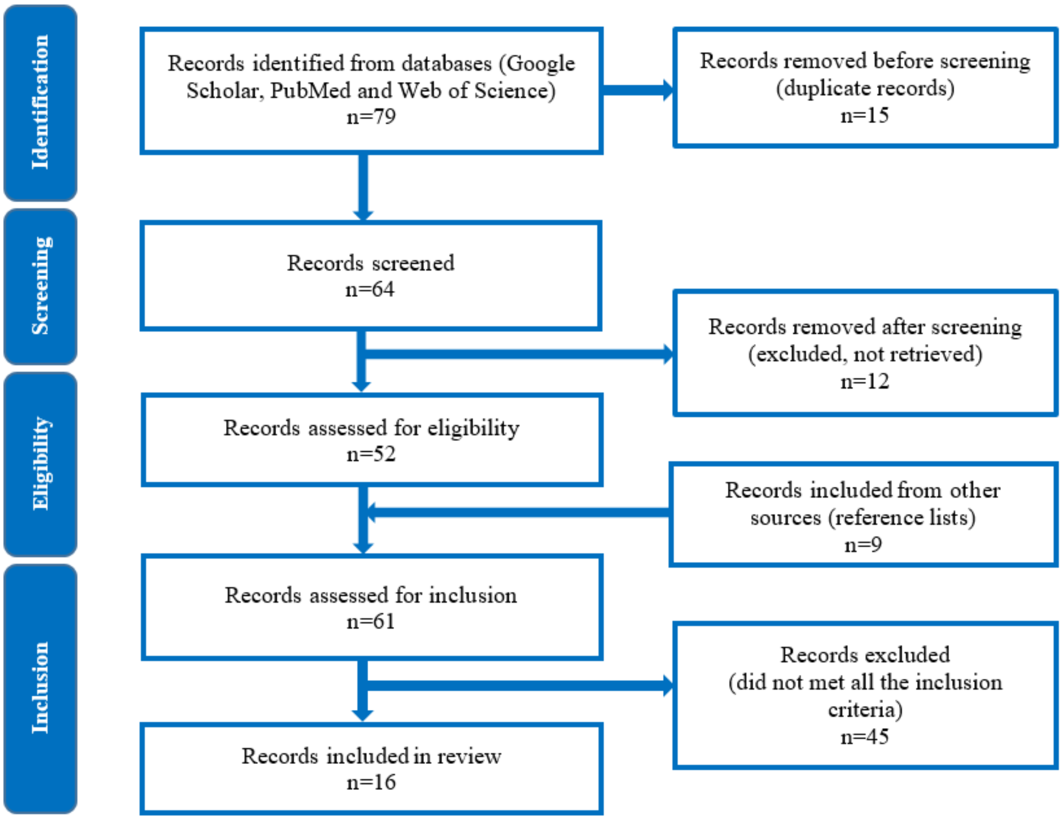

Figure 1. Flowchart for the selection of records

The scientific material taken into account highlights that so far the following training methods have been used to increase fencing speed: eccentric and plyometric training, strength training, core strength training, speed training, agility training, instability resistance training, fitness training, circuit training, ballistic and dynamic stretch training (during warm-up), functional training, bilateral transfer training, SAQ (speed, agility, quickness) training. Some research was carried out with innovative training and evaluation methods, thus identifying conditions and factors that favourably influenced speed.

Table 1 presents the main information that supports the effectiveness of certain interventions made in the training programmes to increase fencing speed.

The main characteristics of the studies included in the review are shown in Table 1.

Table 1. *Main characteristics of the studies included in the review*

Source	Participants	Methods	Results
Balkó et al., 2017	n =19 fencers (épée) 12 M, 16 ± 1.1 yr. 7 F, 16.4 ± 0.9 yr. SG (n = 14) CG (n = 5)	SG: reaction time training CG: traditional training Duration: 9 weeks	Better choice reaction time (CRT) in SG compared to CG ($p = 0.116$) and baseline ($p = 0.013$)
Di Cagnio et al., 2020	n = 54 fencers (foil) (M) IG (n = 26), 17.3 ± 1.9 yr. PG (n = 28), 17.6 ± 2.7 yr.	IG: accentuated eccentric training with a rotary inertial device PG: plyometric training Duration: 6 weeks	Shorter time advance - advance lunge without weapon in IG ($p < 0.001$) Longer distance advance - advance lunge without weapon in SG ($p = 0.00005$) Better execution speed in IG
Elfateh, 2016	n = 30 fencers (F) 17.8 ± 1.9 yr. SG (n = 15) CG (n = 15)	SG: instability resistance training (BOSU ball) CG: traditional training Duration: 10 weeks	Better static and dynamic balance, lunge and footwork in SG ($p < 0.05$)
Guan et al., 2018	n = 19 fencers (épée) (M) 18 yr. Elite fencers (n = 7) Intermediate-level fencers (n = 12)	Lunge speed and biomechanics were measured	Results showed that the HPV (horizontal peak velocity) of elite fencers was significantly higher than in intermediate-level fencers ($p < 0.001$)
Hamza, 2013	n = 18 fencers 13.2 ± 1.9 yr. SG1 (n = 6) SG2 (n = 6) CG (n = 6)	SG1: core strength training with a sling (Swiss ball and bodyweight exercises) SG2: core strength training with no sling CG: traditional training Duration: 10 weeks	Core strength training (SG1 and SG2) increased static and dynamic strength, core strength and lunge speed ($p < 0.05$) Only for lunge performance speed, SG1 increased more than SG2 ($p < 0.05$)
Mohamed & Larion, 2018	m = 20 fencers (épée) 20.12 ± 1.23 yr. SG (n = 10) CG (n = 10)	SG: SAQ training CG: traditional training Duration: 10 weeks	SAQ training improved coordination, agility, movement speed, back strength and performance level ($p < 0.05$)
Murugesan & Jothi, 2019	n = 20 fencers SG (n = 10) CG (n = 10)	SG: circuit training (3/week) CG: regular physical training Duration: 8 weeks	Better speed and speed endurance in SG ($p < 0.05$)
Patial et al., 2019	n = 60 fencers (épée) (M) 16 ± 2 yr. SG (n = 30) CG (n = 30)	SG: Yoga training CG: traditional training Duration: 8 weeks	SG significantly improved fencers' speed ($p < 0.05$)
Redondo et al., 2014	n = 12 fencers (M) SG (n = 6), 24 ± 7.2 yr. CG (n = 6), 22.3 ± 8.1 yr.	SG: maximal strength training and explosive power training (2/week) CG: standard physical conditioning programme Duration: 12 weeks	Maximal strength and explosive power were better in SG ($p < 0.05$)
Sajit et al., 2009	n = 16 fencers (épée) (F) SG (n = 8) CG (n = 8)	SG: a repetitive training method for maximum intensity CG: traditional training Duration: 6 weeks	Better rapid ability of the weapon arm ($p = 0.021$) and attack accuracy ($p = 0.011$) in SG
Sorel et al., 2019	n = 11 fencers 22 ± 3 yr.	Lunge accuracy and response time were measured with an innovative simulator performing lunges in fixed, moving and uncertain conditions	Accuracy and success decreased significantly while moving and in uncertain conditions and were negatively correlated with reaction speed ($p < 0.05$)

Table 1 (continued). *Main characteristics of the studies included in the review*

Source	Participants	Methods	Results
Torun et al., 2012	n = 45 fencers (17 F, 28 M) 11.04 ± 0.93 yr. BFG (n = 15) STG (n = 15) CG (n = 15)	BFG: basic fencing training STG: speed training CG: traditional training Duration: 8 weeks	BFG had better intragroup upper-limb reaction time (p = 0.002) STG had better intragroup reaction time for both the upper (p = 0.011) and lower limbs (p = 0.022)
Tsolakis et al., 2010	n = 20 fencers 21.7 ± 3.4 yr. (10 M, 10 F)	Two different warm-up methods (either static or ballistic stretching) for the quadriceps, hamstring and gastrocnemius muscles	Time on the Sit-and-Reach test (pre-post) (p = 0.001) and Shuttle test (p = 0.036) for both types In male fencers: greater squat jump, reactive strength index, power of lunge and on the Shuttle test (p < 0.001)
Turna, 2020	N = 48 fencers (24 M, 24 F) SG (n = 24) (12M) CG (n = -24) (12M)	SG: agility training CG: traditional training Duration: 6 weeks	Better agility, simple reaction time and multiple reaction time in SG post-test (p < 0.05)
Witkowski et al., 2020	n = 32 fencers (foil) (16 F, 16 M) SG (n = 16) CG (n = 16)	SG: transfer training CG: traditional training Duration: 6 weeks	Increased accuracy of the hits and movement speed with the dominant arm in SG (post-test) (p < 0.05)
Yas et al., 2020	n = 14 fencers SG (n = 7) CG (n = 7)	SG: use of an innovative method to develop the speed of the kinetic response to the skill of stabbing with a shish weapon CG: traditional training Duration: 8 weeks	SG had better reaction speed in post-test (p < 0.05)

Legend: n = number of participants; M = male; F = female; CG = control group; SG = study group; IG - inertial group; PG - plyometric group; yr.= years

Discussion

Motor reaction, speed, explosive power and movement accuracy play an important role in determining fencing success (Singer, 1968; Tuner et al., 2013). Reaction time is essential "because a faster reaction can reduce the total movement time" (Turna, 2020, p. 128). It is unanimously accepted that experienced fencers are faster and better than novice fencers in terms of information processing. Elite fencers show better sequential coordination of the upper and lower limb movements, with more coherent patterns of muscle activation compared to beginner fencers (Chen et al., 2017). Guilhem et al. (2014) state that neuromuscular coordination in elite fencers produces higher magnitudes of forward linear velocity of the body centre of mass and weapon, which is why training should focus on explosive power. In addition, constant efforts have been made to find new solutions to increase speed and agility in all categories of fencing.

Most studies investigating methods of increasing speed in fencing compared the effects of traditional training with its various changes or by alternating it with other types of training. Most of the interventions were made over a period of 6-12 weeks and commonly used fencers who performed traditional training as control groups. None of them explicitly referred to a particular weapon but to fencing in general.

Following the analysis undertaken, we have observed that there is very little research comparing the concrete effects of different types of training for the development of speed in fencing and there are no systematic reviews or meta-analyses studying this information.

Of all the interventions made in the fencing training programmes, some were effective for increasing speed. Thus:

- Eccentric and plyometric training produced a significant improvement in fencing-specific speed movements; these types of workouts increased the lunge length but the time needed to perform them remained the same (di Cagnio et al., 2020). This was obviously also due to increased speed; this training modality, as a variation of training means, could be recommended for young fencers. According to Turner et al. (2013), plyometrics and Olympic-style lifts are one of the most effective forms of ballistic training, which can be adapted to different branches of sport and induce full acceleration through the entire movement.
- Within 12 weeks, strength training based on maximal and explosive exercises determined a significant increase in reaction speed, correlated with increased maximal and explosive power (Redondo et al., 2014); strength training is recommended to be used because it is a basic component of sports training and can lead to performance. Guilhem et al. (2014) and Guan et al. (2018) demonstrate that knee biomechanics is crucial for lunge performance and assert the importance of strength and explosive power training, especially for knee and hip extensors. A low *en-garde* position and a full extension of the rear knee joint during the lunge are suggested to improve the horizontal peak velocity of the centre of gravity and therefore the fencer's speed.
- Core strength training induced an increased lunge performance speed (Hamza, 2013).
- The training intervention of yoga practices had statistically significant effects on the selected physical fitness components: speed, coordination, balance, grip strength, agility and flexibility. Yoga practices play a vital role in improving the speed, coordination, balance, grip strength, agility and flexibility of fencing athletes (Patial et al., 2019).
- Specific and non-specific exercises were used in speed training, and reaction speed was assessed for both the lower and upper limbs. The results showed that, compared to traditional training where an increase in reaction speed was obtained only for the upper limbs, speed training significantly increased reaction speed for all limbs (Torun et al., 2012).
- Within 6 weeks, agility training led to significant improvements in simple and multiple reaction time. "In addition to traditional fencing training, agility training can provide performance advantages to the athletes." (Turna, 2020, p. 133)
- In the study by Witkowski et al. (2020), bilateral transfer training applied for 6 weeks led to a significant increase in accuracy and speed for the dexterous hand thrust; however, the effect was in the short term because, 4 weeks after the programme, there was no statistically significant difference between the dexterous and non-dexterous hand. Research on motor coordination shows that both hemispheres of the brain are involved in controlling the action of each upper limb, so a transfer (interhemispheric) training programme can effectively improve the accuracy of fencing actions, at least in the early stages of training (Witkowski et al., 2017).

- SAQ training, based on exercises for the development of speed, agility and quickness, improved strength, coordination, agility and speed in all its forms (Mohamed & Larion, 2018); this type of training can be used individually, therefore there are training methods for each of its components.
- Instability resistance training, consisting of exercises performed with the Bosu ball, improved static and dynamic balance but also the performance level of basic fencing elements, including speed (Elfateh, 2016).
- Circuit training led to a significant increase in lunge speed (Murugesan & Jothi, 2019).

In addition to these findings, a preliminary study conducted on one female fencer who benefited from a functional training system with modified exercise for fencing (with kettle bells and rope) produced a better movement quality during single-leg movements and also improved dynamic leap and balance (Agosti & Autuori, 2020). However, more reliable results in this area require more research.

The results of the study by Tsolakis et al. (2010) deny the hypothesis that static or ballistic stretching in the later stages of general warm-up leads to increased specific performance in fencing. However, they recommend any type of stretching with a maximum duration of 60 seconds for each muscle, followed by a rest period of at least 5 minutes before any other activity, without fear of affecting the speed and power of fencing athletes.

The use of modern testing methods has led to highlighting the correlations between speed and specific biomechanical parameters; these aspects justify both the use of such methods in the training of athletes and the indirect influence of speed by modifying certain biomechanical aspects of fencing-specific movements. Sorel et al. (2019) used an innovative simulator for performing lunges in fixed, moving and uncertain conditions; they assessed lunge accuracy, response time, execution time and maximum sword velocity, demonstrating that accuracy and success decreased significantly in moving and uncertain conditions compared to fixed ones and were negatively correlated with the reaction speed of fencers. The above authors concluded that training with a simulator in uncertain and moving conditions could induce better accuracy, reaction time and response time, therefore better speed. Such stimulators can adapt the athlete’s attack to the opponent’s movement and increase reaction speed and execution speed. Another innovative method to develop the speed of the kinetic response to the skill of stabbing with a shish weapon was used by Yas et al. (2020) on beginner fencers and showed that using a device to implement exercises led to better results than the specific training without such devices.

The limitations of the aforementioned articles are related to: 1. the low number of studies that have investigated the effects of the same training method on fencing speed, therefore the impossibility of performing a meta-analysis; 2. the fact that most studies in which the control group has done traditional fencing training do not describe this type of training, knowing that it can be quite different; 3. the relatively small number of participants in most of the selected studies - although specific to this sport, it can affect the reliability of the results.

Conclusion

An essential element that contributes to fencing performance is speed optimisation. To this end, besides traditional training methods, various interventions have been made over time in the training programmes of fencing athletes; of these, both those dedicated to increasing speed and those for developing muscle strength, agility, instability resistance, bilateral transfer or circuit training have proven to be effective. Adding static or ballistic stretching elements in the warm-up sequence or using training simulators has also induced an increase in speed.

Given that speed is determined by a multitude of sensory, psychological, neurological, articular and muscular factors, it is impossible to find a single element responsible for increasing speed. We can conclude that complementary interventions towards as many determinants of speed as possible could bring the desired results.

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