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Influence of proprioceptive training on fencing athlete's performance: a clinical trial

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ABSTRACT
Background: Fencing is an agility sport and is characterized by a combination of short and frequent high intensity movements. Proprioceptive training demonstrates a positive effect on athletes' performance. It is effective in increasing dynamic balance by reducing ankle muscle reaction time that stabilize joint. **Objective:** The aim of this study was to verify influence of a 12-week proprioceptive training program on ankle instability, jumping performance and ankle muscle's reaction time during Lunge in fencing athletes. **Method:** The study was a clinical trial, non-randomized, with 19 fencing athletes from 14-35-year-old, divided in intervention group (n=10) and control group (n=9). The study was performed in four stages: familiarization of jump performance; pre-intervention; intervention and post-intervention. At pre-intervention was evaluated jump performance, ankle muscle reaction time and functional ankle instability. At the intervention, athletes performed 30 minutes of proprioceptive training for 12 weeks, three times a week. At post-intervention, the same pre-intervention tests were performed. Data were presented in mean and standard error, submitted to the Generalized Estimates Equations test with Bonferroni post hoc. The level of significance was 0,05. **Results:** Jump performance decreased significantly in both groups. Anterior tibial muscle reaction time did not differ neither in any of groups, nor in any of legs. The peroneus longus and lateral gastrocnemius reaction time decreased significantly in both groups. Regarding functional ankle instability, athletes had instability at pre- and post-intervention time. **Conclusion:** Proprioceptive training program was not able to improve jump performance, nor to decrease ankle muscle reaction time or improve athletes' perception of ankle stability.
Keywords: Proprioception; reaction time; athletic performance; athletic injuries; ankle injuries.

BACKGROUND

Fencing is an agility sport and is characterized by a combination of short and frequent high intensity movements[1]. Success in this sport requires intense repetitive practice of dynamic movements, such as lunge and jumps, to improve and maintain performance[2]. These movements, with rhythmic direction alterations[3], cause lower limb muscles activation by stretching-shortening cycles, which influence propulsion phase (concentric contraction) in the next lunge. It shows that speed, muscle strength and neuromuscular coordination are important parameters for maximizing lower limbs power during performance in fencing[4].

Because of this muscular exposure to repetitive and powerful movements, musculoskeletal system becomes vulnerable to injury, usually, as a result of [5].

In fencing, according to Zemper and Harmer[6] and Harmer et al.[7], approximately half of all injuries occur in lower limbs, especially in knee and ankle, and that the most frequent injury was ankle sprain. This may be associated with sport characteristic (acceleration and breaking actions, and changes direction). Ankle sprain limits athletes, of any modality, in their ability to run, jump, kick and change directions[8], decreasing their performance or even taking them away from the sport for a period.

One way to prevent injuries, especially ankle sprain, is proprioceptive training programs, which can be used both for ankle sprain rehabilitation and prevention[9,10]. Proprioceptive training also demonstrates a positive effect on athletes' performance. It is effective in increasing dynamic balance by reducing ankle muscle reaction time that stabilize joint[11-14].

Regarding the effects of proprioceptive training on jumping performance, Myer et al.[15] compared plyometrics training with proprioceptive training effects through the drop vertical test and medial drop landing tests, applied before and after a seven-week training period. They observed that two training groups significantly improved lower limb alignment after seven weeks, and from this improvement in lower limb biomechanics inferred that lower limb injuries can be prevented. In addition to Myer et al.[15], Cressey et al.[16] also investigated ten-weeks proprioceptive training effects on athlete performance. They used drop vertical jump (DVJ), countermovement jump (CMJ) and 10 and 40-yard sprint time in pre and post intervention. The group that performed proprioceptive training demonstrated significant improvement in DVJ and CMJ, and a significant decrease in the time of the 40-yard sprint.

Therefore, the aim of this study was to verify influence of a 12-week proprioceptive training program on ankle instability, jumping performance and reaction time during lunge in fencing athletes. It was hypothesized that 12-week proprioceptive training program would result in improvement in the perception of joint instability and jumping performance, and reduction in reaction time.

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METHODS

Study design

The study was a non-randomized clinical trial.

Participants and inclusion and exclusion criteria

The population was fencing team, composed of 22 athletes of a multi-sports club who participating in national and international competitions. The inclusion criteria were to practice fencing for at least a year and to be between 14 and 35 years old. The exclusion criteria were to perform physical therapy or participating in preventive programs, have injury in lower limbs that compromised the performance of the tests and missed three consecutive or five alternate sessions of the training program.

Setting

The study was performed in Exercise Research Laboratory at University.

Procedures

All athletes who met criteria and agreed to participate were included in the study, totaling 19 fencers, divided into two groups: intervention group (IG) and control group (CG).

The study was developed in four stages: (1) familiarization; (2) pre-intervention; (3) intervention and (4) post-intervention. On the first day, athletes were allocated, for convenience, in IG or in CG. On the same day, they performed familiarization with drop vertical jump test (DVJT). One week later, at pre-intervention, they realized evaluation of Functional Ankle Instability (FAI), DVJT performance and ankle muscle's reaction time (RT) during Lunge Test. A week after the test, started the intervention stage, which consisted of a twelve-week proprioceptive training program. After a twelve-week intervention (post-intervention) the same pre-intervention stage evaluation was performed.

The outcomes were functional ankle instability, jump performance and reaction time. Functional ankle instability was assessed using Cumberland Ankle Instability Tools (CAIT) questionnaire, a version translated and adapted to Portuguese by Noronha et al.[17] Scores ≥ 28 indicate stability, while scores ≤ 27 indicate functional ankle instability[18].

Jump performance was investigated through DVJT in Jump System Pro 1 model (Cefise - Nova Odessa, São Paulo, Brazil). The participant stood on boxes, 30cm, 40cm and 50cm high, performed a jump, landing on contact area and afterwards performed a vertical jump. The jump should reach the highest vertical height and end with the feet in platform contact area.[19] Three maximum jumps were performed at each box height, with one-minute intervals, and the highest jump height was recorded as final result.

For reaction time evaluation, during the Lunge test execution, ankle muscles electrical activity was recorded. The Lunge Test consists of performing attack gesture of fencing[20]. Participants performed Lunge Test three times and movement should be performed immediately after athlete identified a visual stimulus synchronized with electromyograph, which was triggered by researcher. The peroneus longus (evertor), anterior tibial (dorsal flexor) and lateral gastrocnemius (plantar flexor) electrical activity of front and back leg was collected from an 8-channel Miotool surface electromyograph (Miotec, Porto Alegre, Brazil). Electromyographic activity data during lunge execution were recorded and later analyzed using Miograph software (Miotec, Porto Alegre, Brazil). Electrodes were used in a bipolar configuration [21]. For eletrodes fixation, SENIAM Project parameters (seniam.org)[22] were used. On anterior tibial was 1/3 above line between fibula head and medial malleolus.

On peroneus longus was placed 1/4 on line between fibula head and lateral malleolus. Lateral gastrocnemius electrodes were fixed 1/3 on line between fibula head and heel. Reference electrode was positioned on anterior tibial tuberosity.

Intervention consisted in a proprioceptive training program for fencing athletes selected for IG. This program was adapted from training program proposed by Hupperets, Verhagen and van Mechelen[23], which consisted of 14 exercises, divided into four categories (without material/with specific material of sport/with disc/proprioceptive disc proprioceptive and sport specific material) and with intensity progression each week. It was developed for 12 weeks, three times a week, applied during athletes' warm-up, in a 30-minute session. Each week, three exercises of 14 adapted to fencing athletes were chosen. Training program was applied by the same researcher over 12 weeks.

Statistical analysis

Statistical analysis was performed using SPSS® software version 18.0. Data analysis followed the intention-to-treat principle. Data were presented in mean and 95% CI and submitted to the Shapiro-Wilk test in order to verify their normality.

Independent t-test was used to compare characterization variables of sample. For analysis of variables in different stages (pre and post) and between groups (intervention and control), Generalized Estimates Equations test with Bonferroni *post hoc* was applied. The level of significance was 0.05.

Ethical considerations

Before participating, athletes were invited to read and to sign Consent Form. Athletes under 18, could sign Consent Form, but Consent Form had to be signed by their legal responsible. All athletes who met criteria and agreed to participate were included in the study.

RESULTS

Among fencing athletes, ten were allocated in IG and nine in CG. In Figure 1, is presented the participant´s flow during study.

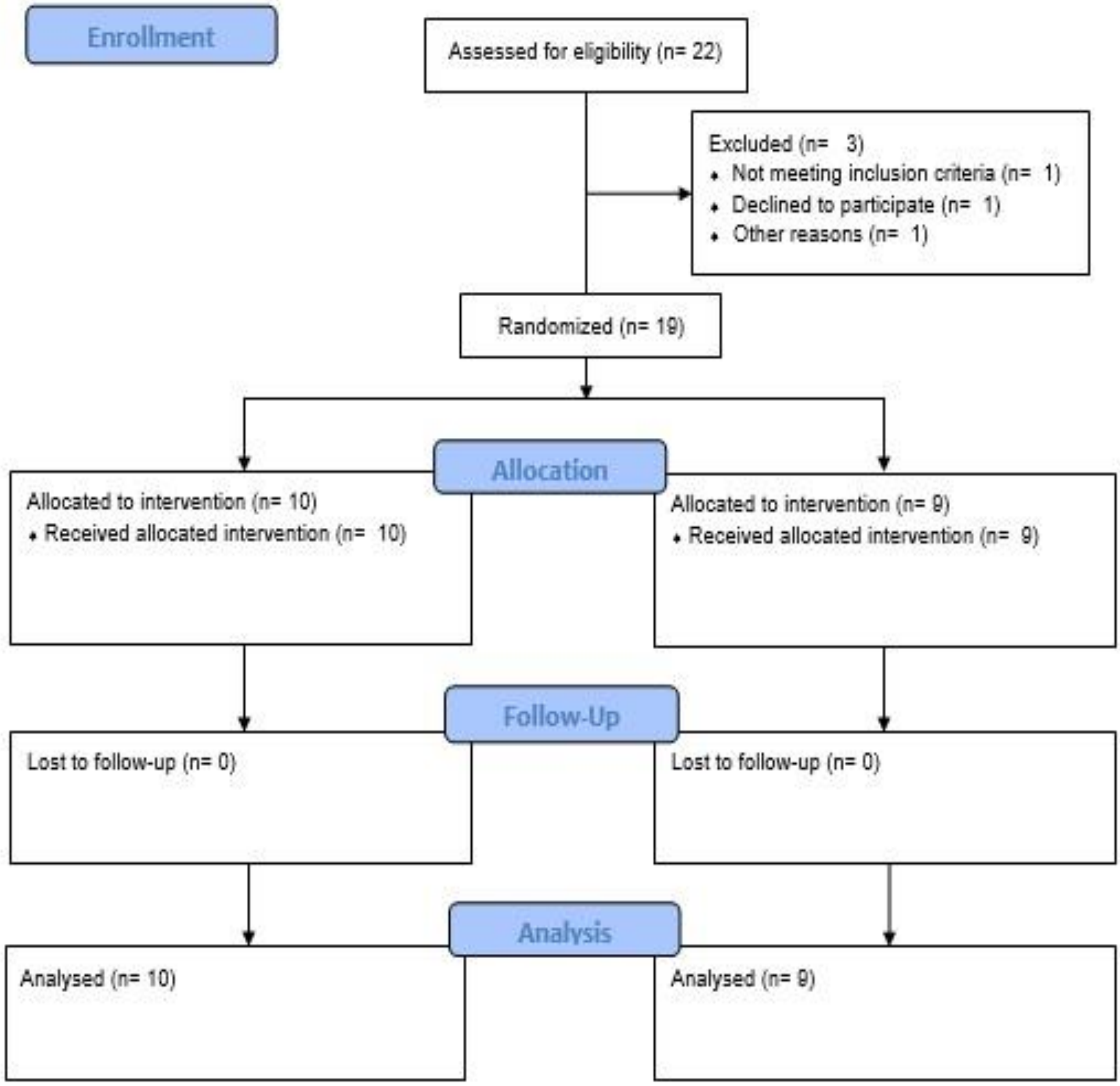

Figure 1. Participant's flow during each study stage.

Sample characterization, related to sex, age, height, weight and time of training is presented in Table 1. Regarding training characteristics, both groups trained together, 100% of athletes trained five times a week, on average three hours a day and competed more than four times a year. In addition to specific fencing technical training, all athletes (100%) performed physical training and weight training, as part of training at club.

Table 1. Demographic characteristics of participants (mean±SD).

	Intervention Group (n=10)	Control Group (n=9)	p
Sex			
Male	6	7	
Female	4	2	
Age (years)	16,80±2,34	24,00±6,65	0,012*
Height (m)	1,74±0,10	1,76±0,04	0,64
Mass (Kg)	69,04±11,37	70,22±10,55	0,81
Time of experience in sport			
4 -5 years	30%	11.1%	
6- 7 years	20%	0%	
> 8 years	50%	88.8%	

***Note:** *p≤0,05.

Regarding CAIT data, no significant differences were observed between groups in front leg, at pre-intervention. 80% (n= 8) of IG athletes presented FAI and 20% (n= 2) presented stability. While, in CG 44,4% (n= 4) presented FAI and 55,5% (n= 5) stability (p= 0,10). In back leg, there were not significant differences between groups (p=0,11) at pre-intervention. In IG, 70% (n=7) presented FAI and 30% (n= 3) stability. Whereas in CG, 33,3% (n= 3) presented FAI and 66,7% (n= 9) stability.

At post-intervention, results were identical in both front and back leg, in which IG athletes showed 80% (n=8) of FAI and 20% (n=2) of stability, while CG athletes had 55,6% (n= 5) of FAI and 44,4% (n=4) stability. There was not significant difference between groups in both front leg (p=0,25) and back leg (p=0,25).

In jump performance, there was not significant difference (p> 0,05) between groups and between group and moment, in any of box's heights (Table 2).

Table 2. Mean and standard error (mean ± SE) of Drop Vertical Jump Test (30cm, 40cm and 50cm) height (cm).

	Intervention Group		**Control Group**	
	Pre (n=10)	**Post (n=10)**	**Pre (n=9)**	**Post (n=9)**
Jump				
30cm	25,21±1,41	24,80±1,40	26,78±1,73	25,03±1,73
40cm	26,95±1,46	26,71±1,42	27,38±1,83	27,15±0,83
50cm	27,24±1,40	26,79±1,48	27,80±1,84	26,77±1,40

***Note:** *p≤0,05.

Anterior tibial, peroneus longus and lateral gastrocnemius reaction time data during the Lunge Test are presented in Table 3.

Table 3. Mean and standard error (mean ± SE) of front and back legs muscle reaction time (ms).

	Intervention Group		**Control Group**	
	Pre (n=10)	**Post (n=10)**	**Pre (n=9)**	**Post (n=9)**
Reaction Time				
Front Leg				
Anterior Tibial	0,15±0,01	0,17±0,04	0,15±0,15	0,18±0,02
Peroneus Longus	0,30±0,06	0,33±0,05	0,39±0,05	0,28±0,04
Lateral Gastrocnemius	0,36±0,05	0,42±0,06	0,39±0,05	0,37±0,03*
Back Leg				
Anterior Tibial	0,18±0,02	0,19±0,06	0,29±0,06	0,28±0,07
Peroneus Longus	0,21±0,03	0,25±0,05	0,26±0,03	0,25±0,04
Lateral Gastrocnemius	0,28±0,05	0,37±0,10	0,27±0,04	0,30±0,06

*p≤0,05.

DISCUSSION

This study investigated influence of a 12-week proprioceptive training program on functional ankle instability, jumping performance, and ankle muscle reaction time during Lunge in fencing athletes. Stimulus generated by this proprioceptive program was not able to increase athletes' perception of ankle joint stability, to improve jumping performance, or to decrease ankle muscle reaction time in Lunge execution.

Regarding data obtained through CAIT, it can be identified that athletes of both groups had ankle instability at all evaluation moments, indicating that proprioceptive training was not able to improve athletes´ perception in relation to ankle stability. Based on literature[10, 24], proprioceptive training is effective to reduce ankle sprains incidence. Therefore, expectation was that after 12 weeks of proprioceptive training, athletes could perceive greater ankle stability, which was not observed.

Ankle instability is related to evertors, invertors, dorsiflexors and plantiflexors strength deficits, as well as reduction of these muscles' reaction time, especially peroneus longus muscles[25]. And ankle instability can also impaired jumping performance, generating less power in lower limbs[26, 27]. Fencing athletes already presented ankle instability at pre-intervention stage and did not improve after proprioceptive training. From that, it is possible to infer that ankle instability may have contributed to DVJT results, suggesting low sports performance.

In this study, DVJT performance did not change or, still, height reached in jumps decreased significantly from pre- to post-intervention. DVJT is commonly used to quantify anomalous movement patterns[28] and, consequently, musculoskeletal injuries in lower limbs[19]. However, few studies[15,16] have applied jumps as a way of evaluating proprioceptive training effect. Myer et al.[15] applied a 7-week proprioceptive training with volleyball players and Cressey et al.[16] applied 12-week training with soccer players and found improvement in jumping performance. The difference between results of present study and studies cited above can be explained by population evaluated. Although all involve athletes, soccer and volleyball training promotes muscle power stimulation different from fencing training, which allows for better jumping performance.

Regarding jumps heights, Tsolakis, Kostaki and vegenas[29] observed that, for elite fencing athletes, in DVJT (40cm) mean height was 30,1cm. In present study probably because they were not professional fencers, DVJT (40 cm) mean values were smaller, with values around 26cm for two groups.

Regarding reaction time, after 12 weeks of proprioceptive training performed in present study, anterior tibialis, peroneus longus and lateral gastrocnemius reaction time of front and back leg did not change significantly. The present study did not observe significant differences between groups in two evaluation stages, however this is different from other studies found in literature[12,13]. Clark and Burden[12] found a significant decrease for anterior tibial and peroneus longus after four weeks of proprioceptive training also in individuals with ankle instability. And in study by Linford et al.[13], after six weeks of proprioceptive training combined with flexibility and strength training in healthy participants, there was also a decrease in peroneus longus reaction time. According to these studies, the proprioceptive training program promotes a reduction in ankle muscle reaction time, especially in individuals with ankle instability.

Among the limitations of the present study, we can cite the fact that the reaction time was evaluated during Lunge and not through the sudden inversion, which is commonly used in literature. Moreover, the number of fencing athletes evaluated and sport characteristic, does not allow to expand results to other populations.

CONCLUSION

The stimulus promoted by proprioceptive training program was not able to increase athletes' perception in relation to ankle joint stability, nor to improve jump performance or to decrease ankle muscle's reaction time during Lunge execution.

Authors Contribution: GSV and CSL conceived the study. GSV, AC, RG and FM performed the assessment. GSV was responsible for the interventions. GSV, AC and CSL were responsible for writing the paper. All authors have read and approved the final manuscript and agreed to be accountable for all aspects of the work.

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