The impact of cone drill training on reaction time and 30-meter sprint performance in youth sprinters

El impacto del entrenamiento con conos en el tiempo de reacción y el rendimiento en la carrera de 30 metros en velocistas juveniles

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Abstract

Introduction: Reaction speed and maximum speed are two fundamental components in influencing the performance of athletes in athletics, especially in the 100-meter sprint. However, until now, effective training models in increasing reaction speed and maximum speed have not been explored to the fullest.
Objective: This study aims to prove the effect of Cone Drill training on reaction speed and maximum speed in 100-meter sprint athletes.
Methodology: This study involved a total of 16 youth sprinter athletes who were participants aged 15–17 years and were given an intervention of Cone Drill training for 6 weeks. Data collection was carried out by measuring 30-m sprint test, while reaction speed using whole body reaction audio and visual carried out before and after the intervention. The parametric paired sample t-test was applied to test the difference in data in each group, while the independent sample t-test was applied to test the difference in data between groups with a significant level of 5%.
Results: The results showed significantly higher 30-meter sprint test and reaction speed between before and after exercise for 6 weeks ($p \leq 0.001$). In addition, we also observed an increase in 30-meter sprint test and reaction speed between groups ($p \leq 0.05$).
Conclusions: These findings prove that the Cone Drill training has a positive impact on increasing reaction speed and 30-meter sprint test, making it one of the training methods that should be considered in the preparation and implementation of the 100-meter sprint athlete training program.

Keywords

Athletics; 30-meter sprint test; physical components; reaction speed; training model.

Resumen

Introducción: La velocidad de reacción y la velocidad máxima son dos componentes fundamentales que influyen en el rendimiento de los deportistas en el atletismo, especialmente en los 100 metros lisos. Sin embargo, hasta ahora no se han explorado al máximo modelos de entrenamiento eficaces para aumentar la velocidad de reacción y la velocidad máxima.
Objetivo: Este estudio tiene como objetivo demostrar el efecto del entrenamiento I of Pain 5 Cone Drill sobre la velocidad de reacción y la velocidad máxima en atletas de velocidad de 100 metros.
Metodología: En este estudio participaron un total de 16 atletas jóvenes velocistas de entre 15 y 17 años de edad que recibieron una intervención de entrenamiento con taladro de 5 conos I of Pain durante 6 semanas. La recopilación de datos se llevó a cabo midiendo la velocidad máxima mediante una prueba de sprint de 30 metros, mientras que la velocidad de reacción mediante la reacción audio y visual de todo el cuerpo se llevó a cabo antes y después de la intervención. Se aplicó la prueba t paramétrica de muestras pareadas para probar la diferencia de datos en cada grupo, mientras que se aplicó la prueba t de muestras independientes para probar la diferencia de datos entre grupos con un nivel significativo del 5%.
Resultados: Los resultados mostraron una mayor velocidad de reacción y en la prueba de sprint de 30 metros entre antes y después del ejercicio durante 6 semanas ($p \leq 0,001$). Además, se observó un aumento en la velocidad de reacción y en la prueba de sprint de 30 metros entre los grupos ($p \leq 0,05$).
Conclusiones: Estos hallazgos demuestran que el ejercicio I of Pain 5 Cone Drill tiene un impacto positivo en el aumento de la velocidad de reacción y la prueba de sprint de 30 metros, por lo que es uno de los métodos de entrenamiento que se deben considerar en la preparación e implementación del programa de entrenamiento del atleta de sprint de 100 metros.

Palabras clave

Atletismo; prueba de 30 metros; componentes físicos; velocidad de reacción; modelo de entrenamiento.

Introduction

Reaction speed and maximum speed are two fundamental components in influencing the performance of athletes in athletics, especially in the 100-meter sprint (Haugen et al., 2019). Sprint is a running race in which all runners run at a very full speed (Bushnell et al., 2007). However, for running, both feet are in a floating position (McDermott et al., 2017). The 100-meter sprint not only tests how fast an athlete can run, but also tests their ability to respond to initial stimuli, such as the sound of a gun starting, as well as their ability to manage acceleration and maintain maximum speed in a short span of time (Tønnessen et al., 2013). This sprint race can be divided into three main phases: the block start and acceleration phase, the maximum speed phase, and the deceleration phase (Healy et al., 2022). In the block start and acceleration phases, athletes strive to achieve optimal speed from a stationary position as quickly as possible. Then, in the maximum speed phase, athletes try to maintain the highest speed they have reached, while in the deceleration phase, they must effectively manage the speed drop until they reach the finish line. The ability to navigate these three phases efficiently is often the main determinant of success in a sprint race (Nagahara et al., 2014).

Reaction speed refers to the time an athlete takes to respond to an external stimulus such as a starting signal, playing a critical role in sprint events (Tønnessen et al., 2013). Even minimal delays in reaction—measured in milliseconds—can significantly affect race outcomes, particularly in high-level competitions. A slow start can hinder optimal acceleration, which is challenging to compensate for in later phases. In contrast, maximum speed involves the athlete's ability to reach and sustain high velocity, requiring a synergy of muscular strength, neuromuscular coordination, and refined technique (Tam & Yao, 2024). Both aspects—reaction speed and maximum speed—are influenced by training programs, which continue to evolve alongside advancements in sports science and technology (Neviantoko et al., 2020). As noted by Maksum & Indahwati (Maksum et al., 2023), athletic achievement is the cumulative outcome of various supporting factors, one of which is the training method. Modern training approaches now emphasize not only strength and endurance but also include agility and coordination exercises (Neviantoko et al., 2020).

One such approach attracting attention is the Five Cone Drill (5CD), an agility-based exercise designed to improve acceleration, deceleration, and directional speed (Diputra et al., 2015). Although the specific use of this drill in sprinting has not been extensively documented, it is characterized by rapid directional changes around five cones, requiring agility, coordination, and fast neuromuscular responses. Some literature suggests that agility training may lead to neurophysiological benefits that could support improvements in reaction and maximum speed. For instance, while Lichtenstein et al. (2023) examined training in older adults, their findings on neuromuscular responsiveness and coordination offer conceptual parallels, although their direct applicability to youth sprint athletes is limited. Similarly, Wu et al. (2024) explored two neural response models, highlighting the role of training in modulating neuroplasticity—insights which, though general, may inform the design of motor control interventions.

The Five Cone Drill (5CD) may potentially work through neurophysiological mechanisms such as increased plasticity in the motor cortex, triggered by exercise-induced calcium ion (Ca^{2+}) dynamics in neurons (Zhou, 2021; Shahrezaei et al., 2006). These processes could accelerate communication between the brain and muscles, as indicated by faster neural signal transmission (Yeom et al., 2020). In addition, this drill might enhance recruitment of type II muscle fibers, known for their rapid contraction capabilities, and increase the efficiency of actin-myosin interactions during muscular contraction (Plotkin et al., 2021). Proprioceptive adaptations—improvements in body position awareness—may also allow athletes to respond more efficiently to directional changes. Furthermore, metabolic enhancements such as increased glycolytic capacity can support faster energy availability during sprints (Yılmaz et al., 2024). While these physiological mechanisms are indirectly associated with reaction speed, more evidence is needed to confirm direct effects on reaction to specific auditory or visual stimuli.

Given the importance of reaction speed and maximum sprint speed for athletic success, exploring effective training methods is essential. The Five Cone Drill (5CD) has been introduced as a method to optimize movement quality through neurophysiological and biomechanical pathways. Although this drill does not directly involve training responses to auditory or visual cues, it may still contribute to improvements in reaction-related performance through enhanced sensorimotor integration. Agility exercises, particularly those involving complex patterns, are known to stimulate rapid central nervous system (CNS) activation and improve the efficiency of neural signal transmission to muscles (Yeom et al., 2020). Previous studies have noted that agility training may improve decision-making speed and proprioceptive response—factors relevant to the sprint start (Lichtenstein et al., 2023). Furthermore, repetitive movement patterns in agility drills are believed to enhance motor cortex plasticity, which could facilitate faster response times across multiple stimulus types, including auditory ones such as the starting gun (Wu et al., 2024). However, limited empirical evidence exists regarding the effectiveness of agility-based drills like the Five Cone Drill for improving reaction time and sprint-specific performance, particularly among youth athletes in their developmental stages. Therefore aims to analyze the effects of Five Cone Drill training on reaction time and 30-meter sprint performance in youth sprinters. It is hypothesized that this agility-based intervention will significantly enhance both variables compared with conventional sprint training. The findings are expected to contribute to the growing body of literature by providing empirical evidence on the neurophysiological mechanisms and practical applications of agility-based training for sprint performance development in young athletes.

Methods

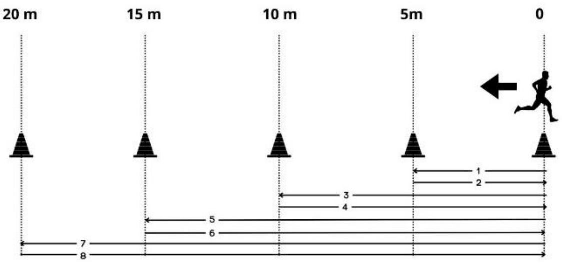
Study design and participants

This study was a true-experimental research with a pretest–posttest control group design. A total of sixteen youth sprinter athletes participated in the study. The inclusion criteria were: age between 15–17 years; body mass index (BMI) between 20–22 kg/m^2; normal systolic and diastolic blood pressure (120–110/90–80 mmHg); resting heart rate (RHR) 60–80 bpm; oxygen saturation 96–100%; and body temperature 36.1–37.0 °C. All participants were verified to have no history of smoking, alcohol consumption, hypertension, or diabetes. Additionally, none of the participants were undergoing any medical treatment or therapy that could influence physiological performance variables. After eligibility screening, participants were randomly assigned into two groups using a simple randomization procedure with a computer-generated random number sequence: an experimental group (n = 8) that received the Five Cone Drill training and a control group (n = 8) that continued their regular sprint training program. Randomization was conducted by an independent researcher who was not involved in the data collection or analysis to minimize allocation bias. All participants completed a six-week training intervention, performed three times per week, under supervision from certified athletic coaches.

Protocol of Cone Drill training

The Cone Drill training was applied with the starting position from the first cone, then go backwards to the second cone with a distance of 5 meters, then run forward to the first cone, then back again to the third cone with a distance of 10 meters from the first cone, then return again to the first cone, then run back again from the first cone to the fourth cone with a distance of 15 meters from the first cone, and finally retreat to the fifth cone with a distance of 20 meters from the first cone, then sprint as fast as possible back to the first cone. This drill was performed for 3 sets of 6 repetitions in each session with 3 minutes rest between repetitions and 3 minutes between sets. The Cone Drill training was applied at high intensity (85–95% maximal aerobic speed / MAS) with a frequency of 3 sessions per week for 6 weeks. Training compliance was monitored by direct supervision of each session, and attendance was recorded to ensure adherence (≥90% participation) to the prescribed training dose. Heart rate and subjective intensity (RPE) were also monitored regularly to maintain the intended training intensity range within the planned protocol. The Cone Drill training procedure can be seen in Figure 1.

Figure 1. Protocol of Training I of Pain 5 Cone Drill



Control group activities

The control group continued with their regular sprint training routine, which included warm-up drills, technical sprint work, and general conditioning (e.g., bodyweight strength exercises), but did not receive any additional agility or cone-based training during the study period. This design aimed to isolate the effects of the I of Pain 5 Cone Drill intervention.

Data collection

Data collection was carried out by measuring reaction speed using a whole-body reaction test (Gavkare et al., 2013). The whole body reaction audio and visual test begins with the preparation of tools such as visual stimuli (lights or screens) and audio (loudspeakers or headphones), as well as a stopwatch to record the reaction time. Participants were given instructions to respond to stimuli as quickly as possible with overall body movements, both to light (visual) and sound (audio) stimuli. The test was carried out by recording the reaction time from the stimulus given until the participant began to move. Meanwhile, the maximum speed was tested using a 30 m sprint test (Ferro et al., 2014; Putera et al., 2023) between pre-exercise and post-exercise. Age, weight, height, body mass index, systolic and diastolic blood pressure, resting heart rate, oxygen saturation, and body temperature were all measured before the intervention.

Data analysis

The normality test was applied with the Shapiro–Wilk test to determine the distribution and centralization of data, while homogeneity was evaluated using Levene's test. The parametric paired sample t-test was applied to examine within-group differences, whereas the independent sample t-test was used to analyze between-group differences. Effect size was calculated using Cohen's d with interpretations of small (0.2), medium (0.5), large (0.8), and very large (1.3) (Sullivan et al., 2012). A priori power analysis was conducted using G*Power 3.1 with a target effect size of $d = 0.80$, a significance level $\alpha = 0.05$, and desired statistical power ≥ 0.80 to verify that the available sample size was sufficient. All statistical analyses used a 5% significance level, and results were presented as mean ± SD.

Results

Data distribution was verified for normality (Shapiro–Wilk) and homogeneity (Levene's test). The results demonstrated significantly higher maximum speed and reaction speed between pre- and post-intervention after 6 weeks of exercise ($p \leq 0.001$) (Figure 2–4). Furthermore, there was also a significant between-group difference in both maximum speed and reaction speed ($p \leq 0.05$). Details of the results of the analysis can be seen in Table 1.

Figure 2. The difference in speed between pre and post in each group
Description: (A) control group. (B) training group. p-value was obtained by paired sample t-test analysis. (*) Significant at pre (p ≤ 0.001).

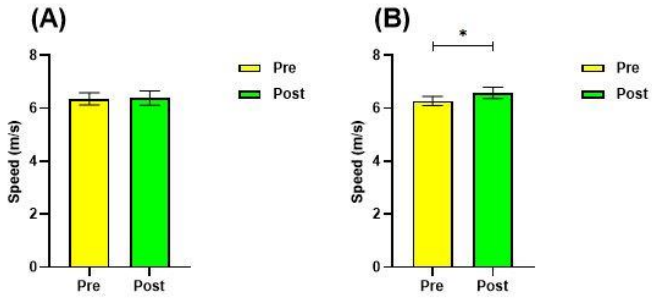


Figure 3. The difference in reaction speed with audio between pre and post in each group
Description: (A) control group. (B) training group. p-value was obtained by paired sample t-test analysis. (*) Significant at pre (p ≤ 0.001).

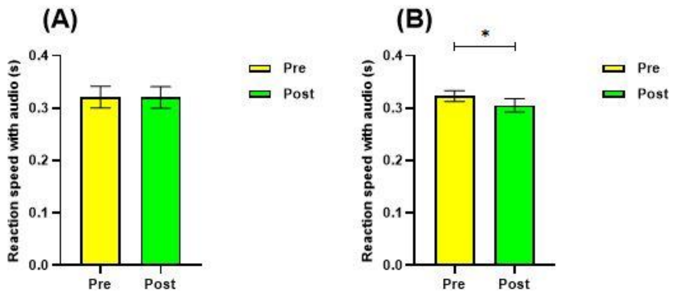


Figure 4. The difference in reaction speed with visual between pre and post in each group
Description: (A) control group. (B) training group. p-value was obtained by paired sample t-test analysis. (*) Significant at pre (p ≤ 0.001).

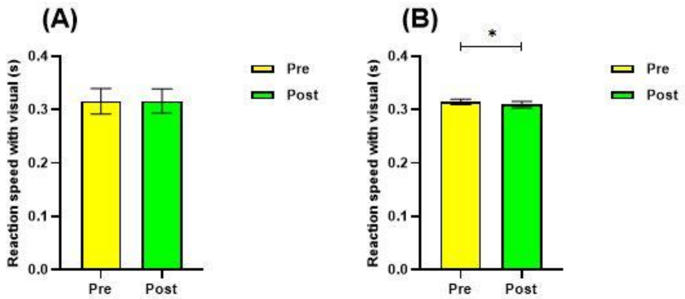


Table 1. Speed analysis results, reaction speed with audio, reaction speed with visual

Variable	Group (n=8)			
	CGp	TGp	P value	Effect size
	mean ± SD	mean ± SD		
Pre-speed (m/s)	6.36±0.23	6.28±0.18	0.412	0.397
Post-speed (m/s)	6.39±0.27	6.58±0.21	0.105	0.812
Δ-speed (m/s)	0.03±0.07	0.31±0.05	0.001	4.537
Pre-reaction speed with audio (s)	0.32±0.02	0.33±0.01	0.809	0.632
Post-reaction speed with audio (s)	0.32±0.02	0.31±0.03	0.101	0.392
Δ-reaction speed with audio (s)	-0.01±0.01	-0.02±0.01*	0.001	5.001
Pre-reaction speed with visual (s)	0.32±0.02	0.31±0.01	0.878	0.632
Post-reaction speed with visual (s)	0.32±0.03	0.31±0.01	0.431	0.447
Δ-reaction speed with visual (s)	0.00±0.00	-0.01±0.01*	0.002	1.938

Evaluation of effect size using Cohen's *d*.
p-value was obtained by independent sample t-test analysis.
Data was displayed with a mean ± SD.
(*) Significant at control group (CGp) (*p* ≤ 0.001).

Discussion

This study demonstrates that the Cone Drill training contributed to improvements in reaction speed and maximum sprint speed among youth sprinter athletes. This form of agility training involves movement patterns requiring rapid changes in direction while managing acceleration and deceleration—key elements relevant to sprinting performance (Wang et al., 2024). However, it is important to clarify that in the study by Wang et al. (2024), the primary focus was on how speed training influences agility, rather than the reverse. While conceptually related, the application of these findings to reaction speed improvement should be interpreted cautiously. Nonetheless, the current study's results indicate that agility-based interventions may indirectly support neuromotor adaptations relevant to sprint performance.

From a neuromuscular perspective, repeated exposure to the Five Cone Drill (5CD) may enhance the nervous system's ability to process and respond to movement stimuli more efficiently, leading to improved reaction time and sprint mechanics (Morat et al., 2020). Although the drill does not include direct auditory or visual stimuli, it appears to stimulate neurophysiological responses—such as increased motor cortex plasticity and improved synaptic transmission—that may support quicker neuromuscular coordination (Li et al., 2024). In addition, the training potentially optimizes the recruitment of type II muscle fibers, which are critical for explosive movements such as sprint starts and rapid acceleration (Skelly et al., 2021; Ross et al., 2021). From a muscle metabolism standpoint, repeated execution of this drill may also enhance glycolytic capacity, potentially leading to faster and more efficient anaerobic energy production. This could help athletes sustain high running speeds for longer periods before the onset of fatigue (Mongold et al., 2024). From a proprioceptive perspective, the training may further improve body awareness and movement coordination, enabling athletes to adjust posture and balance more effectively during directional changes in sprinting. As even minor shifts in posture can affect running efficiency, this adaptation may offer meaningful performance benefits.

Quantitative results further reinforce the observed improvements. Athletes in the intervention group demonstrated a 5% increase in reaction speed—from 0.320 seconds to 0.305 seconds—while the control group improved by only 2%, from 0.315 to 0.309 seconds. Similarly, in the 30-meter sprint test, the experimental group showed a 5% improvement in maximum speed, compared to 2% in the control group. While these differences suggest a favorable effect of the training intervention, further studies with larger samples and statistical power are needed to validate the significance of these results.

These findings align with previous research, such as that by Lee et al. (2024), which found that Speed, Agility, and Quickness (SAQ) training—including cone drills—led to significant improvements in sprint performance over 8 weeks in young female soccer players. The observed parallels support the argument that structured agility drills, including the Five Cone Drill (5CD), may play a role in sprint training regimens. Moreover, this approach reflects the training principles proposed by Suyoko et al. (2022), who emphasize the role of biomotor components—especially speed—in enhancing athletic capacity. Additionally, Morin et al. (2015) demonstrated that sprint acceleration and peak velocity are closely associated with ground reaction forces, which may be positively influenced by directional drills that improve movement mechanics.

The results of this study may suggest that incorporating Five Cone Drill exercises into youth sprint training programs could enhance both reaction time and maximal sprint performance. Coaches might consider implementing this drill during the preparatory or early competition phases, where improvements in acceleration and start performance are most critical. The drill's emphasis on quick directional changes and acceleration–deceleration control could be particularly beneficial for developing neuromuscular coordination and responsiveness among youth athletes who are still refining their motor skills. Moreover, because the drill does not require specialized equipment, it could serve as a practical, low-cost addition to existing training routines. However, its integration should be gradual and tailored to athletes' individual skill levels to avoid overloading and potential movement pattern disruptions.

Although the findings are promising, several limitations should be acknowledged. The sample size was relatively small and drawn from a single athletic club, which may limit the generalizability of the results. The short duration of the intervention (six weeks) also restricts conclusions regarding long-term adaptations. In addition, variables such as motivation, sleep quality, and environmental conditions were not controlled, which could have influenced performance outcomes. The absence of blinding may also introduce bias in data collection.

Future research should consider larger and more diverse participant groups, include longer intervention periods, and possibly integrate neurophysiological measurements (e.g., EMG or EEG) to confirm underlying mechanisms. Studies comparing the Five Cone Drill with other agility-based or resistance training protocols could further clarify its relative efficacy. Longitudinal designs could also help determine whether improvements in reaction time and sprint performance are sustained over competitive seasons.

In conclusion, while acknowledging these limitations, the present findings may suggest that the Five Cone Drill can serve as an effective component of sprint training programs, particularly for enhancing reaction speed and maximum sprint performance in youth athletes. This study contributes to the growing body of knowledge on agility-based interventions and provides preliminary evidence supporting their integration into athletic development frameworks.

Conclusions

This study shows that the Cone Drill training method significantly improves reaction speed and 30-meter sprint test in 100-meter sprint athletes, especially through movement patterns that involve rapid change of direction as well as acceleration and deceleration control. This exercise may be effective effective than conventional methods in improving athletes' neuromuscular abilities. Practically, coaches are advised to integrate the I of Pain 5 Cone Drill in the sprint training program to improve the reaction speed and acceleration of athletes. Meanwhile, future studies suggest using a larger and more diverse sample, longer training duration, and considering psychological factors and exercise conditions to gain a more comprehensive understanding.

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