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Investigation Of The Acute Effects Of Selected Treatments On Reaction Time And Hand Grip Strength In Kickboxers Aged 13-15 Years.

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ABSTRACT

Purpose: The aim of this study is to compare the acute effects of some neurodynamic interventions (caffeine gum, Russian current (EMS), and nerve mobilization) on visual, auditory, mixed reaction times, and hand grip strength in 13-15 year old adolescent kickboxing athletes.

Method: The study was designed using a repeated measures-focused design. The sample consisted of 28 licensed kickboxing athletes (16 men, 12 women; age: 14.10 ± 0.83 years). Participants underwent the following treatments without knowing which method would be applied until the time of application: (1) control conditions (5-minute warm-up), (2) 10 minutes of caffeine gum after a 5-minute warm-up, (3) 10 minutes of Russian current application to the wrist flexors after a 5-minute warm-up, (4) 10 minutes of nerve mobilization exercises for the median and ulnar nerves after a 5-minute warm-up. After each session, reaction time was measured using a Lafayette hand reaction timer and personal strength was measured using a Takei hand dynamometer. Data were analyzed using repeated measures ANOVA and Bonferroni post-hoc test ($p<0.05$).

Results: All intervention groups showed statistically significant improvement in all reaction time parameters and grip strength compared to the control group ($p<0.001$). Nerve mobilization was found to be significantly superior to the other two methods, demonstrating the highest performance in auditory and mixed reaction times (240.14 ± 21.01 ms and 244.17 ± 22.03 ms, respectively) and grip strength (26.16 ± 7.63 kg) ($p<0.05$). While there was no significant difference in nerve mobilization in visual reaction between Russian current (265.64 ± 25.55 ms) and visual response, both were more effective than caffeine gum (274.14 ± 32.13 ms).

Conclusion: In adolescent kickboxers, neural mobilization stands out as the most effective method for achieving acute performance enhancement, particularly in response speed to complex stimuli and hand strength. The Russian stream offers viable alternatives for visual reaction, while caffeine gum provides modest but significant improvements across all parameters. Integrating neural mobilization techniques into warm-up protocols may be beneficial for optimizing neuromuscular preparation in this age group.

Keywords: Caffeine, Russian Current, Nerve Mobilization, Reaction Time, Cognitive Strength.

ÖZET

13-15 Yaş Arası Kick Boksçularda Seçili Uygulamaların Reaksiyon Zamanı Ve El Kavrama Kuvveti Üzerine Akut Etkisinin İncelenmesi

Amaç: Bu çalışmanın amacı, bazı nörodinamik uygulamaların (kafein sakızı, Rus akımı(EMS) ve sinir mobilizasyonu), 13-15 yaş adölesan kick boks sporcularında görsel, işitsel, karma reaksiyon zamanları ve kavrama kuvveti üzerindeki akut etkilerini karşılaştırmaktır.

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Yöntem: Çalışma, tekrarlanan ölçümler odaklı tasarım tasarlandı. Örneklem, 28 lisanslı kickboks sporcusundan (16 erkek, 12 kadın; yaş: 14,10 ± 0,83 yıl) oluşmuştur. Katılımcıların, uygulama zamanına kadar hangi yöntemin uygulanacağını bilmeden, sırasıyla şu uygulamalar yapıldı: (1) kontrol koşulları (5 dakikalık ısınma), (2)5 dakikalık ısınma sonrası 10 dakika kafein sakızı, (3) 5 dakikalık ısınma sonrası el bileği fleksörlerine 10 dakika boyunca Rus akımı uygulaması, (4) 5 dakikalık ısınma sonrası median ve ulnar sinirler için 10 dakika boyunca sinir mobilizasyon egzersizleri. Her seansın ardından, reaksiyon süresi Lafayette el reaksiyon cihazı kullanılarak ve kişisel gücü Takei el dinamometresi kullanılarak ölçüldü. Veriler, tekrarlanan ölçümler ANOVA ve Bonferroni post-hoc testi ($p<0,05$) kullanılarak analiz edildi.
Bulgular: Tüm müdahale grupları, kontrol grubuna kıyasla tüm reaksiyon zamanı parametrelerinde ve kavrama kuvvetinde istatistiksel olarak anlamlı iyileşme sağlamıştır ($p<0,001$). Sinir mobilizasyonu, işitsel ve karma reaksiyon sürelerinde (sırasıyla 240,14 ± 21,01 ms ve 244,17 ± 22,03 ms) ve kavrama kuvvetinde (26,16 ± 7,63 kg) en yüksek performansı göstererek, diğer iki yönteme göre anlamlı derecede üstün bulunmuştur ($p<0,05$). Görsel reaksiyonda sinir mobilizasyonu (256,60 ± 23,02 ms) ile Rus akımı (265,64 ± 25,55 ms) arasında anlamlı fark yokken, her ikisi de kafein sakızından (274,14 ± 32,13 ms) daha etkili olmuştur.
Sonuç: Adölesan kick boksçularda akut performans artışı sağlamada, özellikle karmaşık uyaranlara tepki hızı ve el kuvveti üzerinde sinir mobilizasyonu en etkili yöntem olarak öne çıkmaktadır. Rus akımı görsel reaksiyonda, kafein sakızı ise tüm parametrelerde mütevazı ancak anlamlı iyileşme sağlayarak geçerli alternatifler sunmaktadır. Isınma protokollerine sinir mobilizasyonu tekniklerinin entegrasyonu, bu yaş grubunda nöromüsküler hazırlığı optimize etmek için faydalı olabilir.
Anahtar Kelimeler: Kafein, Rus Akımı, Sinir Mobilizasyonu, Reaksiyon Zamanı, Kavrama Kuvveti.

INTRODUCTION

Kickboxing is a sport that aims to gain an advantage over an opponent by using kicks, knees, elbows, and fists (Rhea et al., 2003). Kickboxing is a complex sport that requires a high tempo, significant energy, and many physical and physiological demands (Colquhoun et al., 2018). Although this sport can be practiced by participants either in competitions or as a recreational activity, it is mostly designed to improve general health, strength, and endurance (Ouergui et al., 2014). Success in this sport requires not only technical and tactical skills, but also the optimal coordination of biomotor attributes such as strength, agility, and reaction time (Slimani et al., 2017). Maximizing these physical and neurophysiological parameters, especially in adolescent athletes aged 13-15, is of great importance for both performance and neuromuscular adaptation (Lloyd and Oliver, 2012). This age group is considered particularly sensitive to external interventions because it is a period when the nerve myelination process is ongoing and nerve conduction velocity reaches adult levels (Malina et al., 2004).

Reaction time refers to the time it takes for a motor response to be generated after any external stimulus, and in sports like kickboxing where even very short times determine the success of a punch, it is considered a component that directly affects success (Rydzik and

Ambroży, 2021). This process involves the perception of visual and auditory stimuli, their processing in the central nervous system to generate a response, and the transmission of that response to motor units as quickly as possible (Schmidt and Wrisberg, 2008). Grip strength, a general indicator of strength for an athlete, is an important element in combat sports such as kickboxing, providing stabilization during defense as well as striking force (Kocaoğlu, 2024).

Caffeine is a frequently used ergogenic aid in sports science because it acts as an adenosine receptor antagonist, increasing central nervous system activation and reducing perceived fatigue level (RPE) (Graham, 2001). Caffeine molecules bind to adenosine receptors in the brain, increasing dopamine release, which in turn enhances the excitability of the motor cortex and shortens reaction times (Volkow et al., 2015). Among the various forms of caffeine applications, caffeine gum is absorbed directly through the oral mucosa and, because it does not require the first-pass metabolism in the liver that traditional capsules undergo, its effect appears much faster (5-15 minutes) (Wickham and Spriet, 2018). This rapid absorption has the potential to provide athletes with an acute advantage, especially during the warm-up period immediately preceding a competition (Ryan et al., 2013).

Russian Current, an electrostimulation (EMS) method, is a medium-frequency electrical current at 2500 Hz that is used to activate muscle fibers and increase maximum force production (Ward and Shkuratova, 2002). The Russian current is applied to increase muscle strength by increasing the depolarization of both sensory and motor nerves and the activation of type 2 muscle fibers (Belanger, 2010). Considering that motor unit activation has not yet reached full capacity, especially in athletes aged 13-15, it is hypothesized that such electrical stimulations can make a significant difference in muscle strength by increasing activity at the neuromuscular junction (Gillen et al., 2019).

Neural stretching or neurodynamic mobilization exercises, which aim to reduce the mechanical sensitivity of nerve tissue and increase its flexibility, aim to allow peripheral nerves to slide freely along their anatomical pathways (Ellis and Hing, 2009). Unlike traditional static stretching, nerve mobilization aims to optimize neural conduction velocity by improving blood flow in the nerve sheath and reducing intraneural edema (Nunez de Arenas-Arroyo et al., 2022). There is theoretical evidence that nerve mobilization can shorten motor response time by increasing neuromuscular interaction and preparing the neural pathway, especially before sudden explosive movements (Waldhelm et al., 2019).

Existing studies reveal that while there are investigations into the effects of caffeine gum on reaction time and grip strength (Field et al., 2024), the effects of EMS method on reaction

time and strength (Kasahara et al., 2021), and the effects of nerve stretching on reaction time and grip strength (Kimura et al., 2002), there is a noticeable lack of research comparing the effects of caffeine gum, Russian wave, and nerve smobilization applications on reaction time and grip strength in the same experimental setup on 13-15 year old kickboxers in their developmental years. It is believed that determining which method elicits a superior neuromuscular response in adolescent athletes will allow coaches to revise their warm-up protocols. In this context, the main objective of the study is to scientifically compare the effects of the three different methods mentioned (chemical stimulation, electrical stimulation, and mechanical mobilization) on the acute performance of young kickboxers.

METHODS

Research Model

This research was conducted using a repeated measures experimental design to investigate the acute effects of selected interventions on reaction time and grip strength in kickboxers aged 13-15 years.

Participants

The research was conducted between November 2025 and December 2025 with 16 male and 12 female kickboxing athletes licensed and registered at the Private Yaycı Sports Club located in the city center of Iğdır. The study's population consisted of kickboxing athletes licensed and registered with the Özel Yaycı Sports Club, and the sample comprised kickboxing athletes aged 13-15. Prior to data collection, participants were provided with both verbal and written information regarding the study's purpose, methods, and ethical principles. Written consent forms were obtained from the families of participants who agreed to participate in the study, voluntarily giving their permission for their children to participate. The study included kickboxing athletes who had been licensed to participate in the Özel Yaycı Sports Club for at least two years. Kickboxing athletes who did not participate voluntarily, did not obtain permission forms from their families, or were injured during the training were excluded. In order to conduct the research, ethical approval was obtained from the XXX University Scientific Research and Publication Ethics Committee before the study commenced (Meeting number: 2025/41 and Date: 09.10.2025).

Study Design

Before the study began, kickboxing athletes undergoing both training and check-ups received a clear explanation, both theoretically and practically, of the study method, procedures to be followed, what to do during the test, and how measurements would be taken. All tests were performed at the same time of day to allow for the termination of the circadian rhythm. Participants were instructed to avoid consuming any supplements (energy drinks, caffeine, etc.) and eating for 3 hours before the tests, to get a good night's sleep (more than 7 minutes of rest) the night before the measurements, and to perform the test protocols with maximum effort. All measurements were taken from the same athletes; randomization was not applied, but a single-blind study was conducted to ensure that athletes were unaware of the methodology up to the point of application. Athletes were not informed which method would be used until it was actually applied. In the first measurement, measurements were taken after a 5-minute warm-up. Participants were asked to refrain from any physical activity other than their daily routine training after the measurements, and a second measurement was taken 3 days later. In the first measurement, participants underwent 10 minutes of Russian current application to the wrist flexor muscles, after which reaction time and grip strength were measured. In the third measurement, participants were measured after a 5-minute warm-up followed by 10 minutes of median and ulnar nerve stretching. Three days later, after a 5-minute warm-up, participants were asked to chew caffeine gum for 10 minutes, and the measurements were repeated using the same procedure. After each session, reaction time was measured with a Lafayette hand reaction device and grip strength with a Takei hand dynamometer. Data were analyzed using ANOVA for repeated measures and Bonferroni post-hoc test ($p<0.05$).

Data Collection

A ‘Personal Information Form’ was prepared to determine the demographic characteristics of the participants, and their gender, age, height, weight, and sports experience were recorded on this form before the measurement. Seca brand portable height measuring device was used to measure the height of the kickboxing athletes participating in the study. Measurements were taken in an anatomical position, barefoot, with breath held, and with the headrest touching the head. Digital Seca brand devices were used to measure the body weight of the men in both the training and control groups participating in the study, both at the pre-test and post-test. Measurements were taken while wearing appropriate sportswear and shoes, and recorded in kilograms (kg).

Reaction Time Measurement (LaFayette Hand Reaction Device): The device in front of the participant contains visual and auditory stimuli. The participant was asked to press a button held 3 cm away from the device each time a light turned on. The best value was recorded from 4 trials. After that, they were asked to press the button every time they heard a sound, and the best value was recorded. Finally, a mixed test was conducted. Participants were asked to press a button without knowing whether a visual or auditory stimulus would appear, and the best value was recorded (Shelton and Kumar, 2010).

Grip Strength Measurement (Takei Hand Dynamometer): Participants were asked to grip with their dominant hand at their sides, with their arms at a 10-15 degree angle from the shoulder, applying the maximum force they could without any support. This test was administered three times, and the best value was recorded (ACSM, 2012).

Application Methods

Caffeine gum: The safe intake of caffeine is stated as 45-85 mg/day for children aged 6-12 years and 2.5 mg/kg/day for those over 12 years of age (Mitchel et al., 2014). It is stated that it is safe when used within this dose range (3-9 mg/kg), but consuming doses above 9 mg/kg does not improve performance and may lead to decreased performance due to negative side effects such as anxiety, headache, nausea or insomnia, vomiting, hypertension, hypotension, and hyperactivity (Maughan et al., 2018). The caffeine gum used in our application contains 150 mg, which is considered a low dose (3 mg/kg) and falls within the recommended limits. Participants chewed caffeine gum for 10 minutes after a 5-minute warm-up, and performance measurements were then taken immediately afterward (Shiu et al., 2024).

Russian current: In the Russian current procedure, One electrode was placed on the medial epicondyle, where the flexor muscles insert, and the other on the palmar surface of the wrist, and the current was increased until the flexor muscles were contracted, and performance measurements were taken after 10 minutes of application (Ward and Shkuratova, 2002).

Nerve mobilization: After a 5-minute warm-up, participants performed stretching exercises for the ulnar and median nerves in specific positions on their upper extremities. The patient was instructed to sit upright with their arms extended and elbows straight, providing access to the ulnar nerve. They were then asked to place their hand on their face with their thumb and index finger joined, the other fingers extended, and the palm facing the roof, with the eye positioned between the thumb and index finger. For stretching, the wrist was forced into extension in this position. For the median nerve, the participant was positioned in an upright

seated position with the arm in abduction and the elbow in full extension. While in this position, the wrist was extended and the head was brought into lateral flexion on the opposite side. Each stretch was performed for 6 seconds, 10 repetitions were considered as 1 set, and 4 sets were performed for each nerve (Coppieters and Butler, 2008).

Data Analysis

In this study, analysis of variance (ANOVA) was performed to examine the effects of different treatments on reaction time and gripping strength. Normality and homogeneity of variance tests were performed to verify the accuracy of the parametric test assumptions. ormality was examined using the Kolmogorov-Smirnov test, and homogeneity of variance was examined using the Levene test; since the p-values obtained in both tests were greater than 0.05, it was determined that the data exhibited a normal distribution and that the variances were homogeneous. In the power analysis performed using G*Power (version 3.1.9.7) software, a moderate effect size was assumed (f = 0.25), significance level $\alpha = 0.05$, statistical power $(1-\beta) = 0.85$, number of measurements = 4, inter-measurement correlation = 0.50, and non-sphericity correction $\varepsilon = 1$. The analysis revealed that at least 26 participants were needed to detect a statistically significant difference. For significance analysis of data after different application methods, repeated measures ANOVA test was applied, and Post-Hoc Bonferroni test was applied to find differences between groups. All analyses were performed using IBM SPSS Statistics 27.0.

RESULTS

Table 1. Average of participants' age, height, weight, and sports age values.

Variable	Mean ± Standard Deviation
Size	165,03± 8,58
Age	14,10 ± 0,83
Weight	56,32 ± 9,73
Sports Age	2,32 ± 1,18

Table 1 presents data on the basic anthropometric and demographic characteristics of the individuals participating in the study. The average height of the participants was determined to be 165.03 ± 8.58 cm, the average age was 14.10 ± 0.83, the average weight was 56.32 ± 9.73 kg, and the average sports involvement age was 2.32 ± 1.18 years. The data indicate that the study group consisted of young, active individuals with a sports background. The standard deviations in participants' height and weight values indicate some variability among individuals in the group; however, they show a homogeneous distribution in terms of age and years of

experience in sports. These characteristics indicate that the sample profile is suitable for the validity of the study and for intergroup comparisons.

Table 2. Visual Reaction Time Values of Participants According to Application Methods

Variable (Ms)	Group	X	SS	Min.	Max.	P
Visual Reaction Time	Control (a)	298,39	42,47	281	314	0,001*
	Caffein Gum(b)	274,14	32,13	261	286	d,c <b<a
	Russian Current (c)	265,64	25,55	255	275	
	Nerve Mobilization (d)	256,60	23,02	247	265	

a, b, c: Different letters in the same column indicate differences between groups ($p<0.05$). A lower reaction time represents better performance.

According to the analysis results, there is a statistically significant difference in the visual reaction time parameter between the control group, caffeine gum, Russian current, and nerve mobilization applications ($p<0.001$). According to the results of the post-hoc analysis conducted to determine which interventions showed a difference, the control group (298.39 ± 42.47) had a significantly longer reaction time than all other groups (Control – caffeine gum: $p=0.001$; control – Russian current and control – nerve mobilization: $p<0.001$). While there was a significant difference between caffeine gum application (274.14 ± 32.13) and Russian current (265.64 ± 25.55) ($p=0.03$) and nerve mobilization applications (256.60 ± 23.02) ($p<0.001$), no significant difference was found between Russian current and nerve mobilization ($p=0.05$). The calculated partial eta-squared value ($\eta^2 = 0.55$) indicates that the effects of the treatments on reaction time are very strong. Based on these results, it can be said that caffeine gum application was more effective than the control group in terms of visual reaction time parameter, while Russian current and nerve mobilization applications showed no significant difference between them.

Table 3. Auditory Reaction Time Values of Participants According to Application Methods

Variable(Ms)	Group	X	SS	Min.	Max.	P
Auditory Reaction Time	Control (a)	288,67	37,40	274	303	0,001*
	Caffein Gum (b)	256,78	33,27	243	269	d <b,<a
	Russian Current (c)	253,89	25,66	243	263	
	Nerve Mobilization (d)	240,14	21,01	231	248	

a, b, c: Different letters in the same column indicate differences between groups ($p<0.05$). A lower reaction time represents better performance.

According to the analysis results, there is a statistically significant difference in the auditory reaction time parameter between the control group, caffeine gum, Russian current, and nerve mobilization applications ($p<0.001$). When post-hoc analysis was performed with Bonferroni correction, the control group (288.67 ± 37.40) was found to have a significantly

longer reaction time than all other groups (p<0.001). The results after caffeine gum (256.78 ± 33.27) application were similar to the results after Russian current (253.89 ± 25.66) application (p=1.00); however, a significant difference was found with the values after nerve mobilization (240.14 ± 21.01) (p=0.005). The calculated partial eta-squared value ($\eta^2 = 0.59$) indicates that the effects of the treatments on reaction time are very strong. Based on these results, it can be said that while there was no significant difference between the caffeine gum and Russian current methods compared to the control group, nerve mobilization application was more effective than all other methods in terms of the auditory reaction time parameter.

Table 4. Mixed Reaction Time Values of Participants According to Application Methods

Variable(Ms)	Group	X	SS	Min.	Max.	P
Mixed Reaction Time	**Control (a)**	307,46	50,90	287	327	**0,001***
	Caffein Gum(b)	272,75	33,89	259	285	
	Russian Current(c)	261,25	25,99	251	271	**d<b,c<a**
	Nerve Mobilization (d)	244,17	22,03	235	252	

a, b, c: Different letters in the same column indicate differences between groups (p<0.05). A lower reaction time represents better performance.

According to the analysis results, there is a statistically significant difference in the mixed reaction time parameter between the control group, caffeine gum, Russian current, and nerve mobilization applications (p<0.001). In post-hoc comparisons, the control group (307.46 ± 50.90) had significantly longer reaction times than all other treatments (p<0.001). The results after caffeine gum (272.75 ± 33.89) application were similar to the results after Russian current (261.25 ± 25.99) application (p=0.06); however, a significant difference was found with the values after nerve mobilization (244.17 ± 22.03) (p<0.001). The calculated partial eta-squared value ($\eta^2 = 0.56$) indicates that the effects of the treatments on reaction time are very strong. Based on these results, it can be said that while there was no significant difference between the caffeine gum and Russian current methods compared to the control group, nerve mobilization application was more effective than all other methods in terms of the mixed reaction time parameter.

Table 5. Participants' Hand Grip Strength Values According to Application Methods

Variable (Kg)	Group	X	SS	Min.	Max.	P
Hand Grip Strength	**Control (a)**	23,35	7,49	20,44	26,25	**0,001***
	Caffein Gum (b)	24,46	7,63	21,50	27,42	**d <b,c<a**
	Russian Current(c)	25,16	7,55	22,23	28,09	
	Nerve Mobilization (d)	26,16	7,63	23,20	29,12	

a, b, c: Different letters in the same column indicate differences between groups (p<0.05). A higher value for grip strength represents better performance.

According to the analysis indicator, there is a significant difference in programming parameter power between the control group, caffeine output, Russian signal, and nerve mobilization applications ($p<0.001$). In post-hoc comparisons, the control group (23.35 ± 7.49) measurements were found to have significantly lower grip strength values compared to all applications ($p<0.05$). The results after caffeine gum (24.46 ± 7.63) application were similar to the results after Russian current (25.16 ± 7.55) application ($p=0.06$); however, a significant difference was found with the values after nerve mobilization (26.16 ± 7.63) ($p<0.001$). Hesaplanan kısmi eta-kare değeri ($\eta^2= 0,55$) uygulamaların reaksiyon süresi üzerindeki etkisinin çok güçlü olduğunu göstermektedir. According to these results, it can be said that while there was no significant difference between the caffeine gum and Russian current methods compared to the control group, nerve mobilization application was more effective than all other methods in terms of the grip strength parameter.

DISCUSSION and CONCLUSION

This study investigated the acute effects of caffeine, Russian current (electrical stimulation), and nerve mobilization applications on visual, auditory, mixed reaction times, and grip strength in adolescent kickboxing athletes aged 13-15 years. Reaction time refers to the time it takes for a motor response to be generated after any external stimulus, and in sports like kickboxing where even very short times determine the success of a punch, it is considered a component that directly affects success (Rydzik and Ambroży, 2021). This process involves the perception of visual and auditory stimuli, their processing in the central nervous system to generate a response, and the transmission of that response to motor units as quickly as possible (Schmidt and Wrisberg, 2008). The findings of this study showed that all three interventions resulted in statistically significant improvements in all reaction time parameters compared to the control group. However, the magnitude of the effect and the mechanisms of action varied depending on the type of intervention. According to the findings of the study, nerve mobilization application provided the greatest performance increase in both auditory and mixed reaction times, and was statistically superior to caffeine gum and Russian current applications. In terms of visual response, no significant difference was found between nerve mobilization and Russian current, but both yielded better results than caffeine gum. These results suggest that mechanical priming of the nervous system may be highly effective in accelerating the motor response, particularly to unexpected stimuli (mixed test) and auditory signals.

One of the most striking findings of the current study is that nerve mobilization demonstrates superiority over other interventions, particularly in auditory and mixed reaction

times, as well as grasping strength. This finding is supported by a limited number of current studies focusing on the acute effects of neurodynamic techniques on performance. A study by Waldhelm et al. (2019) reported that neural gliding exercises applied to the upper extremity in healthy individuals resulted in greater improvement in reaction time compared to static stretching. The study suggests that this effect may stem from optimal nerve conduction velocity resulting from mechanical adaptation of nerve tissue and improved intraneural microcirculation along peripheral nerves. In a study conducted by Sevinçli et al. (2025), the acute effects of nerve mobilization techniques applied to the upper extremity on reaction time in healthy young individuals were investigated. This study compared two different forms of nerve mobilization (self-mobilization and performed mobilization); it was found that both forms of nerve mobilization acutely shortened reaction time in healthy young individuals.

A systematic review by Nunez de Arenas-Arroyo et al. (2022) reported that there is strong evidence that neurodynamic mobilization can improve neurophysiological function by reducing edema within the nerve sheath and increasing the gliding capacity of the nerve. In this sense, nerve mobilization exercises, by improving the gliding mechanics of the epineural and perineural tissues of the peripheral nerves and increasing intraneural microcirculation, inevitably optimize nerve conduction velocity (Nunez de Arenas-Arroyo et al., 2022; Bittencourt et al., 2024). Furthermore, considering the ongoing myelination process during adolescence, it is likely that such mechanical mobilizations acutely increase the flexibility of nerve tissue and the efficiency of nerve impulse transmission. However, it can be suggested that this practice may also have positively affected processing speed in the central nervous system by enhancing proprioception (Winter et al., 2022; Zhang et al., 2025).

In this study, the acute positive effect of caffeine gum on reaction time is highly consistent with the known effects of this ergogenic aid on the central nervous system. Recent studies in the literature also support this finding. For example, a study by Field et al. (2024) reported that the use of 200 mg of caffeine gum in semi-professional soccer players resulted in significant improvement in simple and selective reaction time compared to placebo, but could cause a significant decrease in complex decision-making processes. This result reveals an important detail: caffeine can increase motor response speed in the body, but it may affect performance under cognitive load differently. Similarly, a meta-analysis study by Grgic and Pickering (2019), focusing on general muscle strength and performance, showed that acute caffeine intake (3-6 mg/kg) statistically significantly increased isometric grip strength. The modest increase in grip strength observed in this study is consistent with this meta-analytic finding and suggests

that caffeine may promote maximal voluntary muscle contraction by modulating both central stimulation and the pain threshold. Additionally, caffeine gum significantly reduces reaction times compared to the control group by increasing central nervous system excitability through adenosine receptor antagonism and modulating dopaminergic activity (McLellan et al., 2016; Cappelletti et al., 2015). Its rapid absorption through the mucosa (5-15 minutes) in particular supports its usability as a practical ergogenic aid during the pre-competition warm-up period (Yang et al., 2024). However, in this study, it showed a lower effect size compared to nerve mobilization and Russian current. This may indicate that the central effect of caffeine does not outweigh the acute mechanistic advantage of interventions based on direct conditioning of the peripheral neuromuscular unit. Furthermore, individual tolerance and side effect profiles of caffeine may be a limiting factor in performance enhancement (Guest et al., 2021; Xiao et al., 2025).

The application of Russian electromagnetic (EMS) has proven to be as effective as nerve mobilization, especially in visual reaction time. This alternating current, a mid-frequency, burst-modulated current, has the capacity to selectively activate type 2 (fast-twitch) muscle fibers and associated alpha motor neurons (Ward and Shkuratova, 2002). This activation can shorten reaction time by lowering the depolarization threshold at the neuromuscular junction and increasing the motor unit mobilization rate (Shu et al., 2025). It is also thought that EMS applications temporarily increase corticospinal excitability and accelerate sensorimotor integration by stimulating both the relevant muscle tissue and the afferent and efferent nerve pathways innervating it (Saito et al., 2014). Furthermore, considering that motor unit activation is not yet fully developed in adolescent athletes, the potential of EMS as an acute "neuromuscular preparation" tool in this population is noteworthy (Dotan et al., 2012). However, its lower effectiveness compared to nerve mobilization in auditory and mixed tests suggests that the effect of EMS may be more limited to peripheral muscle stimulation and may not have as comprehensive an impact on central processing speed and response to complex stimuli as nerve mobilization.

Grip strength, a general indicator of strength for an athlete, is an important element in combat sports such as kickboxing, providing stabilization during defense as well as striking force (Kocaoğlu, 2024). In this study, a similar sequence to that observed in reaction time is also seen in grip strength performance. The highest increase was recorded in the nerve mobilization group, followed by Russian current and caffeine gum. The control group, however, appeared to have significantly lower force values. Looking at the literature, a study by Gün et

al. (2023) examined the acute effects of neural mobilization on muscle strength, reaction time, and pain threshold in healthy individuals. This study aimed to reveal the potential effects of peripheral nerve mobilization not only on pain and flexibility but also on motor performance and neurophysiological responses. It observed that neural mobilization resulted in increased muscle strength along with a reduction in reaction time. These findings suggest that nerve mobilization can acutely improve the mechanical properties of nerve tissue and neuromuscular communication. This effect can be explained by the mobilization created by the application along the median and ulnar nerves, which improves the innervation of the palmar muscles (especially the m. flexor digitorum profundus and superficialis) or optimizes neuromuscular coordination (Ellis and Hing, 2009; Gün et al., 2023). According to the results of this study, the modest but significant increase in grip strength caused by caffeine gum can be explained by an improvement in the maximal voluntary activation (MVC) rate due to increased central activation (Ding et al., 2025). The shortening of reaction time observed after the application of Russian current suggests that electrical stimulation can acutely alter the readiness of the neuromuscular system. When the literature is examined, the finding of Bircan et al. (2002) in their study on healthy individuals that EMS application resulted in a statistically significant improvement in quadriceps muscle strength in the short term is consistent with the increase in grip strength performance in the present study. This suggests that EMS can positively influence not only the force parameters but also the reactive properties, including the rate of force application.

This study has some limitations. First, the sample size (n=28) and the fact that only one sports club was included in the study may limit the generalizability of the findings to the entire adolescent kickboxing population. Secondly, while the acute effects of the interventions have been studied, the impact of repeated use of these interventions, their duration of effect (chronic effect), or combinations thereof on performance is unknown. Thirdly, the caffeine dose was administered at a fixed rate (150 mg); the effectiveness of doses adjusted for body weight could be evaluated. Future studies, using larger samples from different sports disciplines, could investigate the long-term effects of these interventions and the more specific underlying neurophysiological mechanisms – such as measuring cortical excitability with EEG (Electroencephalography) or TMS (transcortical magnetic stimulation), etc. Furthermore, randomization was not performed in this study because the interventions were administered to all participants in the same order. This situation may limit the internal validity of the findings by preventing the control of possible order effects and carry-over effects. The study did not

analyze participants by gender. This could limit the interpretation of the findings by preventing the identification of potential gender-related differences. In the study, a 3-day (72-hour) rest period was given between applications. The literature reports that neuromuscular electrical stimulation recording can cause changes in muscle function lasting 24-72 hours (Malone et al., 2014). This directed rest period was adopted to minimize the impact of this on muscle function. However, the inability to account for potential waste effects is a limitation that can be completely eliminated.

The findings of this study demonstrated that, compared to traditional warm-up, neurodynamic practices such as caffeine, Russian current, and neural mobilization resulted in acute performance improvements in reaction time and grip strength in 13-15 year old kickboxing athletes. However, there are some differences in their effectiveness levels.

Nerve mobilization has emerged as the most effective method, particularly for improving auditory and mixed reaction times, as well as cognitive ability. This finding suggests that integrating neurodynamic exercises that target the mechanical preparation of the peripheral nervous system into pre-competition warm-up routines could provide a significant advantage, particularly in sports requiring quick decision-making and reactions, such as kickboxing. Russian electromagnetic stimulation (EMS) offers a viable alternative by directly stimulating fast-twitch fibers and associated nerves, thereby positively impacting visual reaction time. While caffeine gum has demonstrated ergogenic effects, it has been associated with a lower performance increase compared to the other two methods. Given its ease of practical application, rapid onset of action, and central stimulating effect, it appears to be a potentially useful option for improving performance parameters, especially in situations where other methods are not feasible. In conclusion, nerve mobilization is considered the superior method for improving acute performance in adolescent kickboxing athletes. Russian stream and caffeine use also appear to have positive effects on acute performance. Coaches and performance specialists should consider incorporating such neurodynamic techniques into warm-up protocols to improve athletes' reaction speed and hand strength-requiring skills. This study contributes to the field by systematically comparing the acute effects of various interventions with differing physiological basis in young athletes, and provides a scientific basis for optimizing performance development. Based on the findings of this study, it is recommended that future research be expanded to include different age groups. Studies conducted on adult and elite athletes, in particular, will increase the generalizability of the

effects of nerve mobilization and other interventions on performance. Furthermore, research including female athletes could contribute to revealing gender-related differences.

In addition, it is important to investigate the effects of long-term applications on chronic adaptations, going beyond the acute effects examined in this study. The effects of integrating nerve mobilization, electromyostimulation, and caffeine use into regular training programs on performance enhancement, injury risk, and neuromuscular adaptations should be examined in detail.

Future research comparing different doses, durations, and application protocols will also make significant contributions to the literature. In particular, the effects of different dosages and timing of caffeinated gum on performance should be evaluated in more detail. Similarly, the synergistic effects of different combinations of EMS and nerve mobilization techniques could be investigated.

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TÜRKÇE UZUN ÖZET

13-15 Yaş Arası Kick Boksçularda Seçili Uygulamaların Reaksiyon Zamanı Ve El Kavrama Kuvveti Üzerine Akut Etkisinin İncelenmesi

Amaç: Reaksiyon zamanı herhangi bir dış uyaran sonrası motor yanıtın oluşturulmasına kadar geçen süreyi ifade etmekte ve kick boks gibi çok kısa zamanların bile vuruş başarısının belirlediği branşlarda başarıyı doğrudan etkileyen bir bileşen olarak kabul edilmektedir. Bir sporcu için genel kuvvet göstergelerinden biri olan kavrama kuvveti, Kick boks gibi mücadele sporlarında vuruş şiddetinin yanında savunma anındaki stabilizasyonu da sağlayan önemli bir unsurdur. Kafein, adenozin reseptör antagonisti olarak çalışarak merkezi sinir sistemi aktivasyonunu artırması ve yorgunluk algısını (RPE) düşürmesi nedeniyle spor bilimlerinde sıklıkla başvurulan ergojenik yardımlardan biridir. Bir elektrostimülasyon (EMS) yöntemi olan Rus Akımı (Russian Current), 2500 Hz frekansında orta frekanslı bir elektrik akımı olup, kas liflerinde aktivasyon sağlayarak maksimal kuvvet üretimini artırmak amacıyla kullanılmaktadır. Sinir dokusunun mekanik hassasiyetini azaltmayı ve esnekliğini artırmayı hedef alan sinir germe (neural stretching) veya nörodinamik mobilizasyon egzersizleri ise, periferik sinirlerin anatomik yolları boyunca serbestçe kaymasını amaçlamaktadır. Bu çalışmanın amacı, bazı nörodinamik uygulamaların (kafein sakızı, Rus akımı(EMS) ve sinir mobilizasyonu), 13-15 yaş adölesan kick boks sporcularında görsel, işitsel, karma reaksiyon zamanları ve el kavrama kuvveti üzerindeki akut etkilerini karşılaştırmaktır.

Yöntem: Araştırma, tekrarlı ölçüm deneysel deseninde tasarlanmıştır. Araştırma, Iğdır il merkezinde bulunan Özel Yaycı Spor Kulübü'ne lisanslı olarak kayıtlı 16 erkek, 12 kadın kick boks sporcusu ile Kasım 2025-Aralık 2025 tarihleri arasında yapılmıştır. Araştırmanın evrenini Özel Yaycı Spor Kulübü'ne lisanslı olarak kayıtlı kick boks sporcuları, örneklemini ise 13-15 yaş arası kick boks sporcuları (16 erkek, 12 kadın; yaş: 14,10 ± 0,83 yıl) oluşturmuştur. Araştırmanın yapılabilmesi için, çalışmaya başlamadan önce Iğdır Üniversitesi Bilimsel Araştırma ve Yayın Etik Kurulu'ndan etik kurul onayı (Toplantı sayısı: 2025/41 ve Tarih: 09.10.2025) alınmıştır. Katılımcılardan testlerden önce herhangi bir uyarıcı tüketimi (enerji içeceği, kafein vb.,) ve yemek yemekten (> 3 saat) kaçınmaları, ölçümlerden bir gece önce iyi uyumaları (> 7 saat), test protokollerini maksimal eforları ile gerçekleştirmeleri istenmiştir. Sporculara hangi yöntemin uygulanacağı yöntem uygulandığı ana kadar açıklanmamıştır. İlk ölçümde 5 dakikalık bir ısınma sonrası herhangi bir yöntem uygulanmadan ölçümler alınmıştır. Ölçümler sonrasında sadece günlük rutin antrenmanları dışında herhangi bir fiziksel aktivite yapmamaları istenen katılımcılara, 3 gün sonra ikinci ölçüm gerçekleştirilmiştir. İkinci ölçüm öncesinde 10 dakika el bileği fleksör kaslarına rus akımı uygulanan katılımcıların hemen

sonrasında reaksiyon zamanı ve kavrama kuvveti ölçümü gerçekleştirilmiştir. Üçüncü ölçümde 5 dakikalık ısınma sonrası 10 dakika boyunca median ve ulnar sinir germesi yapılan katılımcıların ölçümleri yapılmıştır. 3 gün sonrasında ise 5 dakikalık ısınmanın ardından 10 dakika kafein sakızı çiğnemeleri istenen katılımcılara aynı prosedürdeki ölçümler tekrar edilmiştir. Her seans sonrası Lafayette el reaksiyon cihazı ile reaksiyon zamanı ve Takei el dinamometresi ile kavrama kuvveti ölçülmüştür. Veriler, tekrarlı ölçümler için ANOVA ve Bonferroni post-hoc testi ile analiz edilmiştir ($p<0,05$).

Bulgular: Tüm müdahale grupları, kontrol grubuna kıyasla tüm reaksiyon zamanı parametrelerinde ve kavrama kuvvetinde istatistiksel olarak anlamlı iyileşme sağlamıştır ($p<0,001$). Sinir mobilizasyonu, işitsel ve karma reaksiyon sürelerinde (sırasıyla 240,14 ± 21,01 ms ve 244,17 ± 22,03 ms) ve kavrama kuvvetinde (26,16 ± 7,63 kg) en yüksek performansı göstererek, diğer iki yönteme göre anlamlı derecede üstün bulunmuştur ($p<0,05$). Görsel reaksiyonda sinir mobilizasyonu (256,60 ± 23,02 ms) ile Rus akımı (265,64 ± 25,55 ms) arasında anlamlı fark yokken, her ikisi de kafein sakızından (274,14 ± 32,13 ms) daha etkili olmuştur.

Sonuç: Bu çalışmanın bulguları, geleneksel bir ısınmaya kıyasla, kafein, Rus akımı ve sinir mobilizasyonu gibi nörodinamik uygulamaların 13-15 yaş kick boks sporcularında reaksiyon zamanı ve kavrama kuvveti üzerinde akut performans artışı sağladığını göstermiştir. Ancak, etkinlik dereceleri arasında birtakım farklar bulunmaktadır.

Sinir mobilizasyonu, özellikle işitsel ve karma reaksiyon zamanları ile kavrama kuvveti üzerinde en etkili yöntem olarak öne çıkmıştır. Bu bulgu, müsabaka öncesi ısınma rutinlerine, periferik sinir sisteminin mekanik hazırlığını hedef alan nörodinamik egzersizlerin entegre edilmesinin, özellikle hızlı karar verme ve tepki gerektiren kick boks gibi sporlarda önemli bir avantaj sağlayabileceğini düşündürmektedir. Rus akımı (EMS), görsel reaksiyon zamanındaki olumlu etkisiyle, hızlı kasılan lifleri ve ilgili sinirleri doğrudan uyarmak suretiyle geçerli bir alternatif sunmaktadır. Kafein sakızı ise ergojenik etkisini kanıtlamakla birlikte, diğer iki yönteme kıyasla daha düşük bir performans artışı ile ilişkilendirilmiştir. Pratik uygulama kolaylığı, hızlı etki başlangıcı ve merkezi uyarıcı etkisi göz önüne alındığında, özellikle diğer yöntemlerin uygulanamadığı durumlarda performans parametrelerinin arttırılması anlamında faydalı bir seçenek olabileceği görülmektedir.

Sonuç olarak, adölesan kick boks sporcularında akut performansı artırmak amacıyla, sinir mobilizasyonu en üstün yöntem olarak görülmektedir. Rus akımı ve kafein kullanımının da akut performansa olumlu etkileri görülmektedir. Antrenörler ve performans uzmanları,

sporcuların reaksiyon hızı ve el kuvveti gerektiren becerilerini geliştirmek için ısınma protokollerine bu tür nörodinamik teknikleri dahil etmeyi düşünmelidir. Bu çalışma, fizyolojik temelleri farklı olan çeşitli müdahalelerin genç sporculardaki akut etkilerini sistematik olarak karşılaştırması açısından alana katkı sağlamakta ve performans gelişiminin optimizasyonu için bilimsel dayanak sunmaktadır.