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RESEARCH ARTICLE

Investigation of the Effects of Reaction (Spark) and Calisthenic Training on Performance Development in 12-14 Year Old Wrestlers

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Abstract
The purpose of this study is to examine the effects of reaction (spark) and calisthenic training on performance development in wrestling athletes aged 12-14. Fifteen male wrestling athletes who trained regularly and participated in reaction (spark) and calisthenic training at least once during these trainings participated voluntarily in our study. In addition to standard wrestling training, the athletes were given reaction and calisthenic training for 10 weeks and their performances were evaluated with pre-post tests. The measurement parameters include spark reaction test, push-ups, sit-ups, pull-ups, squat jumps, rope jumping, long jump, plank, static squat and hand grip strength tests. For data analysis, the pre- and post-test data of calisthenic training were evaluated with Paired Sample T-Test, while the spark reaction total time and average time data were analyzed with one-way repeated analysis of variance (ANOVA) within the scope of General Linear Modeling and the significance level was accepted as $p<0.05$. The findings showed that there was a statistically significant improvement ($p<0.05$) in the Spark reaction test on the basis of total and average time. In addition, significant improvements were recorded in parameters such as push-ups, rope jumping and squat jump in calisthenic tests ($p<0.05$). No significant difference was found in some parameters such as pull-ups, planks and long jumps. As a result, these findings reveal that reaction and calisthenic training significantly support physical performance in wrestlers in early adolescence.

Keywords
Wrestling, Reaction, Calisthenics, Performance

INTRODUCTION

Wrestling is a struggle between two athletes to defeat their opponents within a certain area, without using tools or equipment, within the framework of rules (Açak et al., 1997). Wrestling is a sport where sudden and rapid movements are intense in a short time, and anaerobic energy systems are mostly active. Therefore, physical characteristics such as strength, speed, endurance, coordination and flexibility are among the basic elements that determine performance for wrestlers. At the same time, tactical thinking, technical knowledge and quick reaction skills to counter the opponent's moves directly affect wrestling success (Ağaboğlu et al., 2010; Akgün, 1992; Akyüz, 2009; Aydos et al., 2009; Baykuş, 1989; Cisa et al., 1987; Johnson & Cisar, 1987).

Reaction time is an important element that refers to the time an individual can respond to a stimulus and is linked to many aspects of athletic performance. Especially in combat sports such as wrestling, reaction time and related skills are one of the critical factors that determine the athlete's level of success. In wrestling, abilities such as predicting the opponent's movements and responding quickly to attacks or defense moves directly affect the effectiveness of the competition (Barna, 2013; Gierczuk & Bujak, 2014; Gierczuk et al., 2012; Mirzaei et al., 2011; Passelergue & Lac, 2012; Whitley & Montano, 1992). While this process occurs with the harmony of cognitive and motor mechanisms, the athlete's physical endurance and coordination capacity are also of great importance (Demirkan et al., 2014; Maria Lopez-Gullon et al., 2011; Starosta, 2005).

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Reaction time measures the athlete's response time to a stimulus and has a decisive role in branches where sudden and complex movements are important, such as wrestling. Being able to respond quickly and appropriately to the opponent's movements in a wrestling match provides an advantage in both defensive and offensive situations. Reaction exercises improve wrestlers' motor skills and increase their effectiveness in matches. Complex reaction time, in particular, supports wrestlers' ability to adapt to variable competition conditions (Kürkçü & Özdağ, 2005).

In wrestling, reaction time includes not only moving quickly, but also being able to anticipate the opponent's intentions and movements. This requires wrestlers to develop their ability to respond instantly to both visual and auditory stimuli. In addition, constantly changing environmental stimuli that occur during competition can affect athletes' attention levels and prolong their reaction times. However, regular and specific reaction exercises can improve athletes' reflexes and increase their ability to make quick decisions. This situation supports the cognitive and motor development of athletes, especially in early adolescence, and creates a permanent effect on performance in the long term (Jain et al., 2015; Sevim, 2010). In studies conducted on youth wrestlers, the importance of reaction training increases even more. Since cognitive and motor development processes are more dynamic in childhood, reaction training conducted in this age group can provide positive contributions not only to athletic success but also to general cognitive capacity (Jehu et al., 2015; Leckie et al., 2014; Prinzmetal et al., 2005; Reigal et al., 2019). In addition, fast and accurate decision-making processes play a decisive role in the acquisition of tactical and technical skills in wrestling (Chaabene et al., 2017). For this reason, reaction training is considered an important training component in order to develop the basic motor skills of child wrestlers and to ensure that they perform more effectively during the fight.

Calisthenic training, consisting of bodyweight-based exercises, plays a crucial role in developing fundamental motor skills such as balance, coordination, muscular endurance, strength, and flexibility in children and adolescents (Dahab & McCambridge, 2009; Guerra et al., 2019). These components are highly relevant in wrestling, where athletes must execute complex motor tasks under high physical demand.

Studies have demonstrated that calisthenic exercises enhance neuromuscular adaptations by improving intra- and intermuscular coordination, which is essential for effective movement control and injury prevention (Faigenbaum & Myer, 2010; Guerra et al., 2019). Particularly in young athletes, strength gains through calisthenics stem largely from neuromuscular adaptations rather than muscle hypertrophy (Myers et al., 2017). This makes calisthenics an optimal training format for early adolescence, a developmental stage marked by rapid neuromotor plasticity.

In the context of wrestling, as in combat sports, the ability to change direction quickly, maintain dynamic balance, and execute explosive movements such as takedowns or escapes are critical. Calisthenic exercises, such as squats, lunges, push-ups, and jumps, target large muscle groups in both the upper and lower extremities and contribute to the development of these sport-specific actions (Akyol et al., 2016; Kaya et al., 2012; Thakur & Vidhale, 2016).

Additionally, calisthenics are adaptable, low-cost, and require minimal equipment, making them highly accessible and ideal for group or individualized training. Their rhythmic and engaging nature also supports long-term adherence, which is vital for developing consistency in motor skill acquisition (Srivastava, 2016). Therefore, integrating calisthenic training into wrestling programs for youth athletes offers not only physical performance benefits but also fosters long-term athletic development.

MATERIALS AND METHODS

Research Design and Participants

This study was conducted with the participation of 15 male wrestling athletes between the ages of 12-14 who regularly train at Harmanören Sports Club. The average age of the participants was determined as 11.93 ± 0.7 years, and the average height was determined as 145.57 ± 6.99 cm. The athletes had at least two years of training experience and regular competition participation. Participation in the study was completely voluntary, and the purpose and importance of the study were explained to the participants in detail and their motivation was increased.

Ethical Approval

The research protocol was approved by the Istanbul Yeni Yüzyıl University Health Sciences Research Ethics Committee at the meeting dated 05.07.2024 and numbered 2024/07-1281, and was carried out within the framework of ethical rules. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Training Program

Participants were given standard wrestling training every weekday for 10 weeks. In addition to these trainings, Reaction (spark) and calisthenic trainings were planned. Each training session was designed to last 90 minutes per day. The trainings were planned to maximize the physiological adaptations of the athletes and support their performance development.

Table 1. Training program

Day	Monday	Tuesday	Thursday	Friday
Warm. (20 min)	-Light jogging (10 min.) exercises to train the main joints -Dynamic stretching (Gymnastic exercises) -Light technical warm-up (Balance and reaction exercises in wrestling position with a partner)	-Light jogging (10 minutes) exercises to train the main joints -Dynamic stretching (gymnastic exercises) -Light reaction exercises (touching the partner's hand or foot, fast foot movements)	-Light jogging (10 minutes) exercises to train the main joints -Dynamic stretching (Gymnastic exercises) - Light technical warm-up (Balance and reaction work in wrestling position with a partner)	- Light jogging (10 min) exercises to train the main joints -Dynamic stretching exercises -Reaction warm-up (catching the ball, responding to partner's commands; single-double leg pull)
Main Section (60 min)	**Reaction (20 min)** - Quick start with partner command (use of light/sound) - Reaction drills to colored cones - Change direction runs with sound (clapping hands) **Coordination and balance (20 min)** - Cat ladder drills - Balance work on one leg (eyes closed/ difficult variations) **Calisthenics (20 min), (3x20)** - Arm Area (Push-ups, chin-ups, rope) - Foot Area (Jump, squat. Deadlift, Lunge)	**Technical-Tactics (30 min).** -Standing-Ground wrestling technical exercises -Repetition: 2 min x 3 -Intensity: 80-90% -Rest: 1 X 1 -Between sets: 6 min rest **Endurance (20 min)** - Pull-push wrestling simulations with a partner - Shuttle run on the mat **Calisthenics (10 min)** - Abdominal Region (Cranch) - Back Region (Piolet, reverse crunch) -Sliding step progression -Kneeling progression	**Reaction (20 min)** - Quick response to partner's change of direction command - Drills for lunging for a moving ball **Calisthenics (40 min) - 3 sets** 5' rest between sets 10 Stations 20sec work 40sec rest (Push-ups, piolet, crunches, pull-ups, reverse crunches, rope, vertical-horizontal jumps, jackknife - Waist twist - Double dip and lift -Paired carries, Resistance band reflex exercises	**Technical-Tactics (20 min).** -Standing-Floor technical work -Repetition: 2 min x 3 -Intensity: 80-90% -Rest: 1 X 1 -Between sets: 6 min rest **Reaction (20 min)** -Long sit on the floor with the back to the mat and a 3-way race with the command "get up" -Facing the coach, the coach holds 2 tennis balls and leaves one in his hand and the athlete catches it without falling to the ground **Calisthenics (20 min)** -Resistance band arm Eccentric, concentric contraction exercises Resistance band foot Eccentric, concentric contraction exercises
Cooling phase (10 min)	-Static stretching and deep breathing exercises.	- Slow paced walking and stretching exercises.	-Slow paced walking and stretching exercises.	-Full body static stretching.

Data Collection And Measurement Methods

Measurements were carried out for two days at the Harmanören Sports Club Milli Egemenlik Wrestling Training Hall. Participants were subjected to a 20-minute standard warm-up protocol before starting the test. All measurements were made within standardized protocols and under appropriate conditions.

Day one

Participants' demographic information and body compositions were recorded with the following parameters:

Height and Body Weight Measurement

Participants' heights were measured with a height-height measurement scale with a precision of 0.01 cm. Body weights were recorded using an electronic scale (SECA, Germany) with a precision of 0.1 kg.

Spark Reaction Test

Participants were subjected to a 20-minute standard warm-up protocol before starting the test, and detailed technical information was provided before the test. All participants were provided with detailed instructions on how to use the device, and they were allowed to perform trial tests on the test devices without any anxiety about high effort before starting the test. The reaction test was applied to measure the participants' reaction time to visual stimuli and their ability to maintain this reaction, and two different measurements were performed during the test;

Measurement where the spark lamps were positioned on the octopus device in front of the participants,

Measurement where the spark lamps were placed on the ground in the same dimensions as the positions on the octopus, so that the participants were in the starting wrestling position.

The participant's name was recorded in the reaction application (program). The device was adjusted so that the participants' right and left arms could easily reach the lamps. Before the test, a 10-second practice test was applied; during this process, randomly lit signals were turned off by touching. The test was started after the practice. During the test, 8 lighted lamps (Sparks) were placed 50 cm from the center and each Spark was lit 3 times, giving a total of 24 random signals. The participants were asked to touch the red color among the randomly lit colors on the 8 Sparks fixed on the device within 10 seconds. The test was terminated when a total of 24 randomly lit signals on the 8 Spark devices were turned off. After the test was completed, the "result scan" section was pressed and the other record showing the reaction result was recorded (Republic of Turkey GSB., 2022)

Day Two

Plank Test (sec)

In the plank test, the participants started the test by lifting the pelvis in a prone position on the wrestling mat, standing on their toes, holding their forearms and elbows at bilateral shoulder width; with their shoulders, back, hips and legs forming a parallel line to the ground. The time elapsed in seconds was recorded if the participant broke their posture or ended the test (Reiman & Manske, 2009).

Push-Up Test (30 sec)

Participants were asked to do maximum push-ups in 30 seconds with their hands open at shoulder width and in a straight body position on the wrestling mat. The chest touching the mat and the elbows fully straightening were counted as one repetition. The number of correct push-ups done in 30 seconds was recorded (Rocha & Guedes Júnior 2013; Zorba & Saygın, 2009).

Sit-Up Test (30 sec)

Participants were asked to start the sit-up test by lying on their backs, knees bent, feet flat on the floor and hands clasped behind their necks. The return of the body to the knees without full contact during the sit-up was considered one repetition. The test continued for 30 seconds and the number of repetitions performed correctly was recorded (Zorba & Saygın, 2009).

Pull-Up Test (Sec)

Participants were asked to try to stand on a chin-up bar that they held at a wide angle while maintaining a 90-degree arm angle, and the time elapsed when the position was disrupted or the participant released the bar was recorded in seconds (Sevim, 2010).

Standing Long Jump Test (Cm)

Participants jumped on the horizontal plane with their feet shoulder-width apart and their knees slightly bent. The jump distance was recorded in cm by measuring the distance between the starting line and the closest point the feet could reach. The best value after two trials was taken into account (Mackenzie, 2005).

Rope Skipping Test (30 sec)

Participants skipped rope with a Selex brand self-counter rope skipping device, jumping with both feet for 30 seconds. The rope cable was

adjusted according to the participant's height. The number of skipped repetitions was recorded (Zorba & Saygın, 2009).

Classic Squat (wall) Test (sec)

Participants waited with their backs against the wall, feet hip-width apart, knees bent at 90 degrees. The time elapsed when the position was broken was recorded in seconds.

***Squatjump Test** (30 sec)*

Participants started in a squat position, jumped up quickly, landed in a controlled manner and returned to the same position, and repeated this movement serially for 30 seconds. Each jump was counted as a completed repetition and the number of repetitions performed correctly was recorded (Mackenzie, 2005)

***Hand Grip Strength Test** (kg)*

Participants' hand grip strengths were measured using a TakeiPhysicalFitness Test (Japanese) hand dynamometer. The dynamometer was adjusted according to the participant's hand size. The participant's arm was straight and at an angle of 10-15 degrees from the shoulder, and he squeezed with all his strength. The value was recorded separately in kg for the right and left hands. The participant performed 2 repetitions with both hands, and the best value was taken into account (Kim et al., 2018).

Data Analysis

SPSS (version 29.0) and Excel (Microsoft Office, version 2023, Microsoft Corp., Redmond, WA, USA) programs were used in the analysis of pre-test and post-test data obtained from the measurements. The effects of reaction and calisthenic training on the performance of the athletes were evaluated with statistical analyzes. The data were recorded in the SPSS program for statistical calculations and analyzed, and the Kolmogorov-Smirnov test was used to examine whether they showed a normal distribution. The test results indicated that all variables met the assumptions of normality ($p > 0.05$), supporting the use of parametric statistical methods. In the analysis of normally distributed data, the pre-test and post-test data of calisthenic training were evaluated with the Paired Sample T-Test, while the Spark reaction total time and average time data were analyzed with one-way repeated analysis of variance (ANOVA) within the scope of General Linear Modeling. The Excel program was used in the classification of the data and the calculation of percentage differences; significance levels were accepted as $p < 0.05$.

RESULTS

When Table 2 is examined, the average age of participants was determined as 11.93 ± 0.7 years. While a statistically significant difference was observed in body weight between the pre- and post-test measurements (**p = .007**), the mean change was minimal ($\Delta\bar{x}$ = 0.07 kg), suggesting that the difference is not practically meaningful. Similarly, the change in height was not statistically significant (**p = .054**). These findings may indicate that the short duration of the intervention was insufficient to produce meaningful changes in basic anthropometric parameters.

Table 2. Descriptive data of athletes

Variables	Test	N	Mean ($\bar{x}$)	SD	t	p-value
Age (year)		15	11.93	.70		
Body Weight (kg)	Pre-test		43.45	9.49	-3.162	.007
	Post-test		43.51	9.47		
Height (cm)	Pre-test		145.53	6.98	-3.162	.054
	Post-test		145.57	6.99		

As seen in Table 3 (Total time/Average time × pre-test/post-test), a statistically significant effect was observed at the 99% confidence level in the comparison of total and average times in the athletes' standing spark reaction test, analyzed through one-way repeated measures ANOVA under the General Linear Model framework (**$F(1,14) = 2847.34$, $p < 0.001$**). According to this result, the athletes' reaction times significantly improved following the training program, with post-test values ($\bar{x}$ = 15.46) being lower than pre-test values ($\bar{x}$ = 18.83). Similarly, average reaction time decreased from 0.78 to 0.64 seconds, indicating a faster response. The analysis revealed that **99.5% of the variance** in test performance could be

attributed to the training intervention (**Partial Eta Squared = 0.995**).

Table 3. Comparison of standing spark reaction test levels of athletes

Variables	n	x̄	sd	Variables	n	x̄	sd	F(1,14)	p	PES
Total Time (Pre)	15	18.83	1.00	Total Time (Post)	15	15.46	1.00	2847.34	<0.001	0.995
Average Time (Pre)		.78	.04	Average Time (Post)		.64	.04			

**p<0,001; PES: PartialEtaSquared

As shown in Table 4, a statistically significant difference was found in the total and average reaction times of the athletes in the leaning-sliding step spark reaction test, based on pre- and post-test comparisons. Analysis using one-way repeated measures ANOVA revealed a large effect size (**F(1,14) = 1620.48, p < 0.001, PES = 0.991**). After the reaction training program, the athletes demonstrated a marked improvement in performance, with the total reaction time decreasing from 22.98 seconds to 14.43 seconds, and the average time improving from 0.95 seconds to 0.59 seconds. These findings suggest that 99.1% of the observed variance can be attributed to the training intervention.

Table 4. Comparison of the reaction test levels of the athletes with the leaning-sliding step

Variables	n	x̄	sd	Variables	n	x̄	sd	F(1,14)	p	PES
Total Time (Pre)	15	22.98	1.79	Total Time (Post)	15	14.43	1.34	1620.48	<0.001	0.991
Average Time (Pre)		.95	.07	Average Time (Post)		.59	.05			

As shown in Table 5, statistically significant improvements were observed in push-up, squat jump, and rope skipping performances (**p < 0.001** for all). These findings suggest that the calisthenic training program effectively enhanced muscular endurance and explosive lower-body strength. However, no significant differences were found in sit-up, pull-up, plank, standing long jump, wall squat, and hand grip strength performances (**p > 0.05**).

Table 5. Pre-test and post-test analyses of calisthenic measurements

Variable	N	Pre-test Mean ± SD	Post-test Mean ± SD	t	df	p-value
Push-up (30sec)	15	17.20 ± 7.50	19.13 ± 7.12	-4.882	14	<0.001
Sit-up (30sec)		24.06 ± 4.63	24.00 ± 4.48	0.323		0.751
Pull-up (sec)		17.26 ± 14.87	16.60 ± 13.70	1.071		0.302
Squat jump (30sec)		18.40 ± 5.22	21.93 ± 5.40	-9.723		<0.001
Rope skipping (30sec)		29.53 ± 13.78	33.26 ± 13.24	-4.879		<0.001
Standing long jump (cm)		153.76 ± 18.57	153.40 ± 18.44	1.434		0.174
Plank (sec)		103.40 ± 55.21	103.26 ± 55.28	0.397		0.698
Classic wall squat (sec)		172.93 ± 110.19	173.00 ± 109.71	-0.250		0.806
Right hand grip (kg)		19.73 ± 2.65	19.72 ± 2.63	0.695		0.499
Left hand grip (kg)		17.29 ± 3.37	17.29 ± 3.35	0.000		1.000

These non-significant results may be explained by the fact that the athletes already incorporated these exercises regularly into their existing wrestling training routines, possibly resulting in a performance plateau. Furthermore, the relatively short duration of the intervention may have been insufficient to elicit measurable changes in some of the parameters that require longer adaptation periods, such as isometric endurance or maximal grip strength.

DISCUSSION

The aim of this study was to investigate the effects of Spark reaction and calisthenic training on the performance of wrestlers aged 12–14. The simultaneous implementation of these two distinct training modalities represents a novel and comprehensive approach, offering both neuromotor and functional strength development within the same training framework (Dahab & McCambridge, 2009; Jain et al., 2015). This integration is particularly valuable given the scarcity of studies combining cognitive-motor and physical conditioning strategies in early adolescent athletes.

In combat sports such as wrestling, where sudden and complex movements are crucial, reaction time constitutes a fundamental element influencing both offensive and defensive strategies. As supported by previous studies, reaction time is critical to the effective execution of technical and tactical maneuvers (Gierczuk & Bujak, 2014; Whitley & Montano, 1992). The ability to anticipate an opponent's movements and respond swiftly provides a significant competitive advantage, particularly under submaximal performance conditions (Gierczuk et al., 2018).

This study demonstrated significant improvements in reaction performance, supporting the notion that reaction training enhances decision-making speed and execution accuracy in wrestling contexts. The findings align with prior literature emphasizing the role of reaction-based training in improving visual-motor coordination and attentional focus (Fong et al., 2013; Jain et al., 2015; Witte et al., 2022). Moreover, consistent with previous studies, Spark reaction training was shown to significantly enhance reflexes and neuromotor responsiveness (Çolakoğlu et al., 1993; Kaya, 2016). These results reaffirm the importance of reaction training in the athletic development of youth wrestlers.

Reaction time, defined as the interval between the onset of a stimulus and the initiation of a response (Bompa, 2007; Tamer, 2000), is influenced by the nature of the stimulus visual, auditory, or tactile. Studies have reported average reaction times of 180 ms for visual, and 140 ms for both auditory and tactile stimuli (Singer, 1980), underlining the necessity for sport-specific reaction training (Magill, 1998; Şahin, 1995). In this regard, the reaction method offers a dynamic, stimulus-rich training environment tailored to the demands of combat sports.

Calisthenic training, on the other hand, yielded marked improvements in physical parameters such as muscular endurance and explosive strength, evidenced by gains in push-ups, rope jumping, and squat jumps ($p < 0.001$). These results support previous research highlighting the effectiveness of calisthenics for neuromuscular adaptation in adolescents (Dahab & McCambridge, 2009; Guerra et al., 2019). The bodyweight-focused nature of calisthenics is especially suited for young athletes, promoting strength, control, and coordination without the need for external load (Duran, 2017; Thakur and Vidhale, 2016).

What sets this study apart is the integrated application of Spark reaction and calisthenic training, which allowed for simultaneous development of cognitive-motor and physical abilities. This dual focus not only enhanced performance parameters independently but also potentially created a synergistic effect where improvements in neuromotor speed may have reinforced physical execution, and vice versa (Bherer et al., 2021; Faigenbaum et al., 2011). Such a combined protocol offers a time-efficient and holistic model for youth athletic training (Fong et al., 2013; Guerra et al., 2019).

However, no statistically significant improvements were observed in parameters such as pull-ups, planks, and long jumps. This may be attributed to athletes' familiarity with these movements from routine wrestling practice. Additionally, the 10-week intervention may have been insufficient to elicit notable gains in well-developed areas. Similar findings by Destaye (2024) also indicate that limited training duration can reduce observable changes in certain physiological parameters.

These findings underscore the importance of training periodization and variability, especially when targeting multiple performance components.

When reaction and calisthenic training are strategically combined, they can form a robust foundation for both cognitive agility and muscular conditioning in youth athletes.

This study's small sample size (N = 15), lack of a control group, and short duration limit the generalizability of the findings. Future research should consider randomized controlled designs, larger samples, and extended interventions to further explore the potential of integrated training models.

The results of this study revealed the complementary and multidimensional benefits of combining Spark reaction and calisthenic training on the performance of 12–14-year-old wrestlers. The integrated approach facilitated improvements in both reaction speed and physical performance, highlighting the unique value of concurrent cognitive-motor and physical conditioning in adolescent athletes (Bompa, 2007; Reigal et al., 2019). This study contributes original insight into the potential of hybrid training models and underscores the importance of designing age-appropriate, holistic development programs. Coaches and practitioners are strongly encouraged to systematically incorporate such integrated methods to maximize athletic performance in early adolescence.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Ethics Statement

The study was approved by the Istanbul Yeni Yüzyıl University Health Sciences Research Ethics Committee (2024/07-1281).

Author Contributions

Study Design: AY, SD; Data Collection: AY, SD; Statistical Analysis: AY, SD; Data Interpretation: AY, SD; Manuscript Preparation: AY, SD; Literature Search: AY, SD. All authors have read and agreed to the published version of the manuscript.

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