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Effects of polarized and pyramidal training, with or without mindfulness, on race time and performance in amateur runners: Protocol for a randomized controlled trial

Efectos de los modelos de entrenamiento polarizado y piramidal con o sin mindfulness, sobre el tiempo de carrera y el rendimiento en corredores recreativos: Protocolo de un ensayo controlado aleatorizado

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Abstract. Problem: Road races in athletics has increased worldwide in recent years, leading to a growth in amateur runners (AR). Despite this growth, research aimed at this population is scarce and has methodological weaknesses. One topic of recent interest in AR is the effects of training intensity distribution (TID) and mindfulness on race time (RT); however, there is not enough evidence to establish a consensus among scientists, trainers, and athletes. Objective: To compare the effects of four training programs with polarized and pyramidal TID models on 10 km RT, ventilatory thresholds one and two, maximum aerobic speed, maximum oxygen consumption and body composition in AR. Method: A randomized controlled clinical trial with four parallel arms. The study groups include two with a polarized TID model and two with a pyramidal TID model, both combined with and without a mindfulness program over 12 weeks. Mindfulness practice will consist of 65 minutes per week through individual sessions and group workshops. Discussion: The practice of recreational athletics is increasing; however, the effect of TID and mindfulness on RT in this population have not been extensively studied.
Keywords: Training intensity distribution, mindfulness, amateur runners, race time, body composition, polarized training, pyramidal training.

Resumen. Problema: Las carreras de calle en atletismo han aumentado a nivel mundial en los últimos años, lo cual ha llevado a un crecimiento de corredores recreativos (AR). A pesar de este crecimiento, las investigaciones dirigidas a esta población son escasas y con debilidades metodológicas. Un tema de interés reciente en los AR son los efectos de la distribución de intensidades del entrenamiento (TID) y el mindfulness sobre el tiempo de carrera (RT), sin embargo, no hay suficiente evidencia que permita un consenso entre científicos, entrenadores y deportistas. Objetivo: Comparar los efectos de cuatro programas de entrenamiento con modelos de TID polarizado y piramidal sobre el RT en 10 km, los umbrales ventilatorios uno y dos, la velocidad aeróbica máxima, el consumo máximo de oxígeno y la composición corporal en AR. Método: Ensayo clínico controlado aleatorizado de cuatro brazos en paralelo. Los grupos de estudio incluyen dos con modelo de TID polarizado y dos con modelo de TID piramidal, ambos combinados con y sin un programa de mindfulness durante 12 semanas. La práctica de mindfulness consistirá en 65 minutos por semana a través de sesiones individuales y talleres grupales. Discusión: La práctica del atletismo recreativo está en aumento; sin embargo, el efecto de TID y el mindfulness sobre el RT en esta población no ha sido estudiado extensamente.
Palabras claves: Distribución de intensidades del entrenamiento, conciencia plena, corredores recreativos, tiempo de carrera, composición corporal, entrenamiento polarizado, entrenamiento piramidal.

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Introduction

Training intensity distribution (TID) is the time an athlete spends in each intensity zone during a period of time (cycle, mesocycle, macrocycle) (Bourgois, et al., 2019; Campos, et al., 2021; Festa, et al., 2020; Filipas, et al., 2022; T. L. Stöggl & Sperlich, 2015). These training zones are three based on the triphasic model (Kinderman, et al., 1979; Skinner & McLellan, 1980) and are defined by physiological parameters such as ventilatory thresholds (VT); ventilatory threshold one (VT1) and ventilatory threshold two (VT2). According to these physiological parameters, the three training zones are: zone one, or low intensity, with intensity <VT1; zone two, or moderate intensity, between VT1 and VT2; and zone three, or high intensity, >VT2.

Different TID models are identified in the literature: the polarized (POL) TID model, where around 80% of total training time is in the low-intensity zone (<VT1), 15-20% in the high intensity zone (>VT2), with no or little time (0-5%) in the moderate intensity zone (between VT1 and VT2) (Garcia et al., 2024; Hydren & Bruce, 2015; Muñoz et al., 2014; Rivera et al., 2021; Röhrken et al., 2020; T. L. Stöggl & Sperlich, 2015; Treff et al., 2019). The pyramidal (PYR) TID model consists of a high percentage of training time in zone one (~80%), with lower proportions in zones two and three (Garcia et al., 2024; Kenneally et al., 2021; T. L. Stöggl & Sperlich, 2015; Treff et al., 2019). The threshold (THR) TID model, unlike previous TID models, focuses a large part (>40%) of training time in zone two, between VT1 and VT2, with the rest in zones one and three (Kenneally et al., 2021; Rivera et al., 2021; T. L. Stöggl & Sperlich, 2015; Treff et al., 2019). The low-volume, high-intensity (HIGH) TID model allocates the highest percentage of training time (50-70%) to zone three (Hydren & Bruce, 2015; Stöggl & Sperlich, 2015; Treff, et al., 2019). Finally, the high-volume, low-intensity (HVT) TID model assigns almost all training time (~100%) to zone one (Hydren & Bruce, 2015; Stöggl & Sperlich, 2015; T. Stöggl

& Sperlich, 2014). In scientific evidence, the POL and PYR TID models are identified as the most effective for long-distance performance in highly trained and elite athletes and are the most used at these levels (Bourgois, et al., 2019; Campos, et al., 2021; Casado, et al., 2022; Haugen, et al., 2022; Muñoz, et al., 2014; K. S. Seiler & Kjerland, 2006; S. Seiler, 2010). However, no studies have compared the PYR TID model with other TID models in amateur runners (AR), and for the POL TID model,, few studies were found (Carnes & Mahoney, 2018; Festa, et al., 2020; Muñoz et al., 2014; Muñoz & Varela-Sanz, 2018; Zinner, et al., 2018).

Findings from these studies showed no statistical differences in race time (RT) between the POL TID model and the THR, HIGH, and HVT models. Only one case study showed an RT improvement favoring the POL model over the THR model in a long-distance athlete (Muñoz & Varela-Sanz, 2018); however, being a case study does not allow generalizations. Regarding TID effects on physiological parameters in AR, no statistical differences in maximum oxygen consumption (VO_2max) were found between the POL, HVT, and HIGH TID models (Zinner, et al., 2018). For maximum aerobic speed (MAS), no statistical differences were observed between the POL and THR TID models (Festa et al., 2020; Muñoz & Varela-Sanz, 2018; Pérez, et al., 2019; Röhrken, et al., 2020). For VT and body composition (BC), no differences were found when comparing the POL and THR TID models (Festa, et al., 2020; Pérez, et al., 2019). In summary, the few studies on recreational athletes show no statistical differences between TID models on the described variables. Another aspect to consider are unrobust research designs, such as the case study (Muñoz & Varela-Sanz, 2018) and the pilot study (Röhrken, et al., 2020).

Moreover, no studies evaluated the effect of combining TID models with mental training strategies (Cruz-González & Arboleda-Serna, 2022). One such strategy to enhance performance in endurance sports is mindfulness, which focuses on present-moment awareness with an attitude of openness, receptivity, non-judgment, and acceptance(Oxford, 2021). These characteristics may help manage pain, fatigue, boredom, and negative cognitions, which can affect long-distance race performance due to the cyclical and prolonged nature of this sport (Wegner, 1994). Only two studies have applied mindfulness in runners: an open trial (De Petrillo, et al., 2009) with 27 participants in an experimental and a control group, completing a weekly mindfulness workshop for four weeks. No differences in RT were found between groups, and a reported limitation was the lack of random assignment due to athlete schedules. The other study (Jones & Parker, 2016) was cross-sectional, where runners completed online questionnaires on best 800 m RT, "catastrophic pain" scale, and mindfulness level. A significant association was found between mindfulness and 800 m RT; however, a limitation was the lack of verification for the reported RT. The limited literature does not allow conclusions about the effect of mindfulness on performance in long-distance runners, nor were TID models manipulated in the interventions.

As shown, evidence on the effect of TID models and mindfulness in AR on RT, performance, and BC is limited, with research designs that do not allow generalization of results (Jones & Parker, 2016; Muñoz & Varela-Sanz, 2018; Röhrken, et al., 2020). No studies tested POL vs. PYR, nor evaluated TID models combined with mindfulness(Cruz-González & Arboleda-Serna, 2022). This research is novel as it is the first randomized controlled trial (RCT) longer than previous studies in AR, comparing the POL and PYR TID models with and without mindfulness.

For this protocol, we present the research objectives and hypotheses, followed by methodological details. Key aspects such as design, eligibility criteria, ethical considerations, recruitment, sample size, study location, randomization, adherence strategies, data management, intervention characteristics, outcome measures, and analysis methods are addressed. Finally, the discussion and limitations are covered.

Objectives

The primary objective of this RCT is to compare the effects of four training programs, two with a POL TID model and two with a PYR TID model, combined with and without a mindfulness program over 12 weeks on 10 km RT in AR. The secondary objective is to assess the effects on VO_2max, MAS, VT and BC.

Hypothesis

In the limited number of studies available, the polarized TID model is recognized as one of the most commonly used by elite runners (Casado et al., 2022). For recreational athletes, the polarized TID model has shown greater improvements in 10 km race times, which is considered important from a practical perspective (Muñoz et al., 2014). Mindfulness, as an emerging strategy in the field of physical activity and sport, is still understudied, but has shown significant associations with improved race times (Jones & Parker, 2016; Oxford, 2021). Considering these findings, and drawing on the research group's 15 years of experience in recreational athletics, the following hypotheses were proposed:

The primary hypothesis states that the POL TID model combined with a mindfulness program (POL+) is superior by at least 60 seconds in the RT in 10 km, compared to the POL TID model without a mindfulness program (POL-), and with the PYR TID model with mindfulness (PYR+) and PYR TID model without mindfulness (PYR-). The secondary hypothesis establishes that the POL+ TID model is superior in VO_2max, MAS, VT and BC compared to the POL- TID model, and with the PYR+ TID and PYR- models.

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Methods

Trial design

Four-arm parallel RCT, designed following CERT and CONSORT guidelines (Moher, et al., 2010; Slade, et al., 2016). Registered with Clinicaltrials.gov under identification number NCT06111144.

Eligibility criteria

Forty athletes will be recruited, including men and women, amateur long-distance runners aged 25-50 years, apparently healthy, with 10 km RT in Bogotá or similar altitude (2600 m above sea level) ranging from 45-60 minutes for men and 50-65 minutes for women. Participants must accept their voluntary participation by signing informed consent before starting the study. The Research Ethics Committee of the University of Antioquia University Institute of Physical Education and Sports in Medellín, Colombia, approved the study protocol (Minutes 42-2023). Athletes who smoke, or have cardiovascular diseases, arrhythmias, heart failure, hypertension, or musculoskeletal problems affecting their participation in the training program will be excluded.

Ethical aspects

The study will adhere to the principles established by the World Medical Association through the Declaration of Helsinki (World Medical Asociation (AMM), 2013) and Resolution 008430 of the Colombian Ministry of Health (Ministerio de Salud Colombiano, 1993). Participants will receive training on the informed consent process, allowing them to authorize their participation with full knowledge of the objectives, justification, potential benefits, and associated risks, ensuring their freedom to choose participation.

Recruiting

Athletes will be recruited from the JC RUNNING TEAM via WhatsApp. Recruitment will close once the required number of volunteers is reached. No payments or incentives will be offered to participate in the study.

Research location

RT evaluations will take place at *El Virrey* Park in Bogotá, Colombia. Evaluations of physiological variables and BC will be carried out in the laboratory of the *Fundación Universitaria del Área Andina* (FUAA). About 80% of interventions will be held at *El Virrey* Park; and the remaining 20% can be conducted in other settings outside Bogotá, given the participants' work activities.

Sample size

The calculation of the sample size was limited by the lack of studies comparing POL and PYR TID models in AR on 10 km RT (Cruz-González & Arboleda-Serna, 2022); only one study compared these models in elite athletes over a 5 km distance (Filipas et al., 2022). A study comparing POL and THR TID models at 10 km was found (Muñoz, et al., 2014). The sample size was calculated in EPIDAT 4.2 using these studies; however, these calculations resulted in very large sample sizes, affecting the research's viability due to time and resource constraints. Based on the research group's experience, a difference of at least 60 seconds in 10 km RT was estimated between the POL TID model with mindfulness and the other TID models. Thus, a viable sample size of 10 subjects per group was defined, totaling 40 AR.

Randomization

The generation of the randomization sequence will be carried out using the sealed enveloped program (Sealed eveloped Ltd., 2021), in blocks of eight and 12 participants, to allocate the 40 AR into four groups: POL+, POL-, PYR+, and PYR-. The randomization sequence will be concealed through opaque, sealed, and sequentially numbered envelopes from 1 to 40 by an independent researcher. Participants will be assigned to groups in the order of their initial evaluations. Coaches supervising the interventions will be blinded to the interventions. All personnel involved will be expert professionals trained in the procedures they will carry out.

Adherence strategies

Ongoing accompaniment and monitoring in person and virtually throughout the research process will be provided, with personalized hours to address concerns. Training loads will be individualized and progressive, based on initial evaluations.

Information management

To ensure privacy and confidentiality, numerical codes will be used to store participants' personal information. Research data will be managed exclusively by the researchers.

Interventions

Four intervention groups will be implemented: POL+, POL-, PYR+ and PYR-. The duration of the intervention for all groups will be 12 weeks. The TID will be controlled by heart rate (HR) for the POL+ and POL- groups as follows: zone one (80%), zone two (5%), and zone three (15%). For the PYR+ and PYR- groups, the distribution will be: zone one (80%), zone two (15%), and zone three (5%), based on the three-zone model. Training periodization for the PYR and POL models will follow a 3:1 weekly block structure, consisting of three load weeks and one recovery week.

The weekly training frequency includes five running sessions, two strength sessions, and two running drills sessions. Running sessions will maintain an equal training volume across the three-week blocks (weeks one to three, five to seven, and nine to eleven). The first week of the block will be five hours/week, the second week will be five-and-a-half hours/week, and the third week will be six hours/week. Recovery weeks (eight and 12) will involve four hours/week, with extensive and variable continuous training, short extensive interval methods I and medium extensive interval methods (Navarro & Garcia, 1998).

Strengthening sessions will take place on Tuesdays and Wednesdays, lasting 50 minutes each week.

Running drills sessions will be conducted on Thursdays and Saturdays, lasting 30 minutes weekly for all 12 weeks (Table 1). Mondays and Fridays will be rest days, though adjustments can be made based on three general rules: (1) Two moderate and high intensity workouts cannot be performed on consecutive days; (2) Five consecutive training days are not permitted; and (3) TID cannot be altered.

Table 1.
Components of interventions with TID models

Training Component	Load Component	Weeks of the Intervention											
		1	2	3	4	5	6	7	8	9	10	11	12
Running	Volume (hours/week)	5	5.5	6	4	5	5.5	6	4	5	5.5	6	4
	Training frequency (sessions/week)	5	5	5	5	5	5	5	5	5	5	5	5
Strength	Volume (minutes/week)	50	50	50	50	50	50	50	50	50	50	50	50
	Training frequency (sessions/week)	2	2	2	2	2	2	2	2	2	2	2	2
Running drills	Volume (minutes/week)	30	30	30	30	30	30	30	30	30	30	30	30
	Training frequency (sessions/week)	2	2	2	2	2	2	2	2	2	2	2	2

In addition to the TID model, the POL+ and PYR+ groups will develop the Mindfulness Running Training Program (MRTP), which consists of 65 minutes per week of mindfulness practice during the 12 weeks of intervention, through four types of individual sessions (Table 2) with audio recordings guiding participants (Cruz et al., 2024). Additionally, three virtual group workshops of 45 minutes each will be conducted. The first session will introduce mindfulness concepts, the MRTP structure, and address questions; the other two sessions will focus on monitoring, evaluating, and providing feedback on MRTP progress.

Table 2.
Overview of the MRTP sessions

Overview of the MRTP sessions							
Session	Type of session	Objective	Moment	Weekly frequency (# sessions)	Days	Session duration (min)	Weekly duration (min)
Stretching – meditation	Body exploration	Practice mindfulness of the present moment through awareness of internal sensations, specifically the muscular engagement of each type of stretch.	Stretching phase of the session	2	Wednesday & Thursday	5	65
Jogging – meditation	Body exploration	Practice present-time mindfulness by focusing attention on internal sensations, muscular engagement, breathing, body movements, and running technique.	Low-intensity running	1	Tuesday	30	
Race – meditation	Meditation	Regulate emotions through awareness and acceptance of thoughts through an attitude of openness, receptivity, curiosity, non-judgment and acceptance.	Moderate- and high-intensity running	1	Saturday	15	
Life – Meditation	Meditation	Focus on attention and full awareness of the present moment with emphasis on internal and external stimuli.	Daily life and free-choice activities	2	Monday and Friday	5	

The programming, follow-up, and monitoring of both the TID and mindfulness programs will be conducted through theTraining Peaks® (TP) application, with support from trainers at the training site. Athletes will wear a GPS smartwatch (Garmin Forerunner 245) during training sessions, which will sync directly with the TP application. After training, the data will automatically upload to the TP platform with various metrics; particular attention will be given to session duration, intensity, and time spent in HR zones. Load quantification will use the training impulse (TRIMP) method (Lucía, et al., 1999; Muñoz Pérez, 2016). Time in zones will be monitored weekly through activity summaries on the TP platform.

Evaluation of outcomes

The evaluations will be conducted on separate days: one for the RT evaluation and another for ergospirometry and BC assessments, separated by at least 72 hours (Table 3). his interval accounts for the necessary recovery of various body systems (muscular, nervous, energetic) after maximal tests, ensuring reliable evaluations (López Chicharro & Fernández Vaquero, 2006).

Table 3.
Evaluation schedule

Week 0 Initial Evaluations	Weeks 1 a 12 Interventions	Week 13 Initial Evaluations
Day 1: Test 10 km Day 2: Ergospirometry and body composition	POL+ POL- PYR+ PYR-	Day 1: Test 10 km Day 2: Ergospirometry and body composition

Evaluation of the 10 km RT (Day one)

This will be carried out as a group. Requirements: Participants must wear light, breathable, and comfortable sports clothing, and shoes designed for running. The same shoes and clothing must be used in both the initial and final tests. Participants will be asked to follow their usual competition breakfast and refrain from physical exercise 24 hours prior. They should also consume at least two liters of fluid daily during the week before the test.

To determine the 10 km RT, participants will run 7.95 laps on the *El Virrey* Park circuit, which measures 1,257 meters. This evaluation will adhere to protocols outlined in the international manual (World Athletics, 2022) to ensure correct execution. Time will be recorded by two evaluators using independent stopwatches (Casio model HS-3V), and the average of these times will be taken as the official result.

Ergospirometry and BC evaluation (Day two)

These assessments will be conducted in the FUAA laboratory. Requirements: Participants should wear sports attire, preferably the same as in the RT evaluation. They should avoid food for at least two hours prior to the BC evaluation, which precedes the ergospirometry test. Participants should not engage in vigorous exercise 24 hours before, or any exercise 12 hours before, and should avoid stimulants or caffeine 24 hours prior. VO_2max, VT, and MAS will be assessed using an incremental test to exhaustion on a 4Front treadmill (Woodway USA, Inc.). VO_2 will be measured breath-by-breath using a K5 portable metabolic system (Cosmed Inc., IL, USA), known for its accurate-to-acceptable reliability across metabolic rates (Winkert, Kamnig, et al., 2020; Winkert, Kirsten, et al., 2020). The K5 will be calibrated according to the manufacturer's recommendations. The protocol starts with a 5-minute warm-up at 5.5 km/h and 1% incline, allowing athletes to walk or jog lightly. The first stage begins at 7.5 km/h with a 2% incline, increasing by 0.8 km/h each minute until exhaustion. Maximality criteria include: VO_2 plateau (<1 ml/min/kg increase despite speed increment), respiratory quotient >1.1, and HR ≥ 95% of predicted maximum HR. VO_2max will be calculated as the average oxygen consumption over the last 30 seconds of the incremental test. VT1 will be defined as the initial rise in the ventilatory oxygen equivalent (VE/VO2) without a simultaneous increase in the ventilatory equivalent for carbon dioxide (VE/VCO2). VT2 will be identified by a second ventilation increase with a rapid rise in VE/VO2 and VE/VCO2 and a decline in partial pressure of exhaled carbon dioxide (PETCO2). MAS will be determined at the VO2max speed. BC will be evaluated using the electrical bioimpedance method (HBF-514C, OMRON), measuring body weight, body mass index, total fat percentage, and skeletal muscle percentage.

Analysis plan

Data analyses will include intention-to-treat and per-protocol analysis (≥85% session compliance for RT, VO_2max, MAS, BC and VT). Shapiro-Wilk and Levene tests will assess normality and homogeneity of variances. Mean differences between groups will be identified using one-way ANOVA with Bonferroni post-hoc tests. Summary measures will be reported as means and standard deviations. Effect sizes will be calculated using Cohen's d: 0.20 (no effect), 0.21–0.49 (small), 0.50–0.70 (moderate), and >0.80 (large effect). If normality and homogeneity of variances assumptions are not met, the Kruskal-Wallis test will be used, and the data will be presented as medians and interquartile ranges. Statistical significance will be set at 0.05 (two-tailed) for all analyses, with a 95% confidence level, using SPSS v27 for Windows.

Discussion

The growth of road races globally has popularized athletics, leading to a 57.8% increase in AR participation, from 5.0 to 7.9 million (Andersen, 2019; Scheerder, et al., 2015). However, training programs for this population are understudied and debated among scientists, athletes, and coaches (Esteve-Lanao, et al., 2007; S. Seiler, 2010; Stöggl & Sperlich, 2015). Recently, the effects of TID and mindfulness on RT, performance variables, and BC, key performance determinants, have gained interest. The evidence is limited to elite athletes, making this research in AR a novel contribution.

It is important to assess the effects of polarized and pyramidal TID models on RT in recreational athletes. Unlike elite athletes, recreational runners often face significant constraints on their training and recovery time due to professional, work, family, and academic commitments. These differences in time availability are key factors that influence how training impacts their performance (Uthurralt, 2022).

One of the advantages of low-intensity training, emphasized in the polarized model, is its potential to reduce the risk of injury and overtraining, even when recovery time is limited for recreational runners (Cruz-González & Arboleda-Serna, 2022; Hydren & Bruce, 2015; S. Seiler, 2010; Sellés Pérez et al., 2019). Low-intensity sessions allow athletes to accumulate greater training volumes over extended periods, helping them maintain consistency without the excessive physical strain often associated with high-intensity training(S. Seiler & Tønnessen, 2009).

In terms of mental training, mindfulness is gaining traction in the fields of exercise and physical activity (Oxford, 2021). For recreational athletes, mindfulness could enhance the quality and effectiveness of limited training time by fostering present-moment awareness, which helps mitigate distractions from daily responsibilities that may interfere with proper training (Hill et al., 2020). Additionally, for inexperienced runners, mindfulness can aid in managing the monotony of low-intensity sessions and improve the handling of fatigue and discomfort during moderate- and high-intensity training (Corbally et al., 2020). Unlike traditional mental training techniques that aim to suppress pain, mindfulness encourages acceptance of pain and non-judgmental awareness, helping athletes let go of negative thoughts, which may positively impact performance (Thompson et al., 2011).

Although both TID models and mindfulness are individually recognized as strategies that can enhance performance, research on their combined effects is scarce. Existing studies have typically focused on one of these two interventions, with no investigations found that evaluate their combined impact—particularly in the context of recreational endurance athletes, the target population of this study

This study will be the first to compare the effects of the POL TID and PYR TID models, both individually and in combination with a mindfulness program, on amateur runners. The research aims to assess their impact on RT, VT, MAS, VO_2max and body composition.

One of the key strengths of this study is its RCT design, which allows for a robust comparison of the effects of the POL and PYR TID models, with or without mindfulness, on RT, performance variables and BC. This design enhances the ability to detect significant differences between the interventions and provides valuable insights into their effectiveness in this specific population.

Limitations

The limitations identified in this study, which researchers cannot control due to financial and resource constraints, include the lack of more robust equipment for evaluating BC, such as dual-energy X-ray absorptiometry, computed tomography, or MRI. However, BC is a secondary outcome in this RCT, so this limitation is not expected to significantly impact the primary objectives of the study. Additionally, we acknowledge that the sample size is limited, primarily due to the high costs associated with the evaluations and the available resources.

Disclaimer

We declare that the opinions presented in the article are our own and do not belong to an official position of the institutions involved.

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Conflict of interest

There is no conflict of interest of the researchers or the participating institutions that are part of this study. The authors are responsible for the content written in this publication.

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