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ORIGINAL ARTICLE

The Effect of Moderate Versus High-Intensity Interval Exercise Intervention on Exercise Motivation, Mental Health, and Quality of Life in Physically Inactive College Students

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ABSTRACT

Background. Despite well-established evidence that high-intensity interval exercise (HIIE) promotes multiple health benefits across various populations, the effectiveness of this protocol, as opposed to moderate-intensity interval exercise (MIIE), on individual wellness and exercise motivation is unclear. **Objectives.** The present study examined the effect of different work intensities on exercise motivation, health-related quality of life (HRQOL), and mental health in physically inactive college students. **Methods.** Twenty-four inactive college students (aged 20.8±1.2 years; PA levels=448±80 MET-min/week) were randomized to 12 weeks of HIIE (n=12; 6-10×1-min work-intervals at 90% of MAS) or MIIE (n=12; 6-10×1-min work-intervals at 60% of MAS), both for three days in a week (36 sessions). All the parameters were measured before and after 12 weeks of exercise intervention. **Results.** HIIE generated more significant improvement in anxiety and depression scores following a 12-week intervention compared to MIIE (all $P<0.001$, all ES>1.25). Also, the HIIE group elicited an improvement from baseline in overall HRQOL variables (all $P<0.03$, ES>0.50) compared to only two HRQOL variables in the MIIE group (all $P<0.04$, ES>0.30). A significant improvement in intrinsic and identified scores was observed after the HIIE intervention (all $P<0.02$, ES>0.57). In contrast, the MIIE group elicited more excellent external and amotivation scores following exercise intervention (all $P<0.02$, ES>0.71). **Conclusion.** The present study's findings establish that the HIIE intervention seems more advantageous in promoting optimal wellness and self-determined motivation among physically inactive college students.

KEYWORDS: ***Interval Exercise, Exercise Motivation, Quality of Life, Mental Health, Self-Determined Motivation.***

INTRODUCTION

The prevalence of physical inactivity among college students has become a serious challenge for education and health authorities across many regions, including China (1, 2). This alarming situation is in line with previous evidence, which indicates a marked reduction in physical activity (PA) participation, with the majority (above 50%) of college students (18–25 years) failing to meet PA recommendations. Indeed, factors associated with academic commitments and social life have led to a difficult situation (i.e., lack of time, energy, and motivation) for many college students to maintain and engage with the PA routines (3). Consequently, recent findings found that college students' physical and mental health levels in China continue to decline (4). These data strengthen the idea that interventions incorporating small daily doses of PA may be a convenient strategy regarding health promotion, especially among college students, given that PA levels are known to decline in this cohort.

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There is currently consistent and robust evidence to suggest that the HIIE protocol is a time-efficient exercise strategy to enhance multiple health benefits, including cardiorespiratory fitness and cardiometabolic diseases across multiple populations (e.g., overweight, children, and clinical populations) (5, 6). HIIE is commonly characterized by an intense bout of exercise (above 85% of maximal effort) interspersed with the recovery interval of low- to moderate exercise (7). The main advantage of the HIIE protocol is that this interval type of exercise can be accomplished within a short period compared to a traditional type of exercise (continuous moderate exercise) while producing similar or greater physiological adaptations. Moreover, Malik and colleagues (8) have revealed that the HIIE protocol generated more excellent exercise motivations (due to a strong feeling of success and excitement) than moderate-intensity exercise in young people. Despite evidence establishing the multiple benefits (i.e., physiological and psychological) of HIIE in well-controlled laboratory environments across various populations, fewer studies have investigated the efficacy of this type of exercise training delivered in a 'real world' setting for young adults (5, 6). Thus, the transferability and practicality of HIIE to college students is unclear.

A recent study has reported that outdoor-based HIIE protocol elicited more excellent cardiorespiratory responses and body composition compared to moderate intensity interval exercise (MIIE) across 12-week exercise interventions in college students (9). This valuable study addressed the issue raised by Jimenez-Pavon and Lavie (10) regarding the role of MIIE protocol as a public health strategy to facilitate health benefits rather than HIIE per se. However, a study by Ming and colleagues (9) is limited to the physical health benefits of college students, and it may not adequately consider the overall impact of interval exercise on individual wellness (e.g., quality of life and mental health). Available data demonstrates the beneficial effects of HIIE on mental health (i.e., stress, anxiety, and depression) and overall quality of life, but these studies were conducted mainly in clinical populations (e.g., cancer patients, heart failure, diabetes mellitus) (11). Moreover, it is currently unclear whether the intensity of interval exercise (i.e., moderate vs high) influences the changes in mental health and quality of life among college students. Considering the need to have better enlightenment about the potential role of interval exercise on wellness and motivation, the primary aim of this study was to compare the effectiveness of 12-week HIIE and MIIE protocols on mental health, quality of life, and exercise motivation among college students.

MATERIALS AND METHODS

Participants. Twenty-four physically inactive Shanxi Technology and Business College, Taiyuan City, China, with no contraindications to exercise according to the Physical Activity Readiness Questionnaire (PAR-Q), volunteered to participate in the present study. Participants were also free from musculoskeletal injuries and had not been involved with any exercise training program for 3 months before the experimental visits. All the participants completed two questionnaires, namely, the PAR-Q to evaluate participants' risk of safely participating during exercise and the International Physical Activity Questionnaire (IPAQ, short version) to ensure the previous physical inactivity of the participants. Subsequently, participants were informed of the aims and potential risks involved in the study before completing their informed written consent to participate. All the study protocols were established in line with the Declaration of Helsinki principles and were

Study Design. The present study utilized a repeated measure, within-subjects, parallel-group design, in which the participants were randomly assigned into two separate groups, namely, high-intensity interval exercise (HIIE group) and moderate-intensity interval exercise (MIIE group). Participants were randomized by gender to ensure a balanced number of men and women in each group. The first experimental visit was to measure cardiorespiratory fitness and anthropometric variables and familiarize myself with the study protocol. This was followed by the completion of a 12- week of HIIE and MIIE interventions, with three exercise sessions per week (total of 36 sessions) in the outdoor-based setting (i.e., soccer field) and separated by a minimum two-day rest period (48 hours) between sessions.

All exercise sessions were performed at a similar time (14:00 to 17:00) of the day to control any potential confounding effects related to the diurnal biological variation. All measurements consisting of mental health (i.e., anxiety, stress, depression), health-related quality of life (HRQOL), and exercise motivation were

completed before and after a 12-week intervention. Standardized instruction was given to the participants at both points to ensure total comprehension of the questionnaires. Participants were also instructed to ask the investigators about any confusion that might arise to the investigators while the questionnaires were being completed. All the procedures were conducted in the same way both times. Participants also refrained from any exercise program during the experimental period.

Anthropometric measurements. Stature and body mass were measured nearest 0.1 cm and 0.1 kg, respectively. Both variables were used to calculate the body mass index (BMI: body mass (kg)/stature (m^2)).

Cardiorespiratory fitness. Participants performed the multi-stage 20-m shuttle run fitness test (20mMSFT) to determine the participant's maximal aerobic speed (MAS) of outdoor running and cardiorespiratory fitness as indicated by the predicted maximal oxygen consumption ($V\dot{O}_{2max}$). The details related to the 20mMSFT and MAS can be found in the recent study by Ming (8).

Depression, anxiety, and stress. The 21-item Depression Anxiety Stress Scale (DASS-21) was adopted to assess the prevalence of stress, anxiety, and depression symptoms among college students. The DASS-21, recently translated and validated into a Chinese version (12), consists of 21 items assessing three negative emotional states (three subscales), each covering seven states. The items are statements related to the subjective assessment of feelings and behavior over the past week. DASS-21 items are rated on a 4-point Likert-type scale ranging from 0 (does not apply to me at all) to 3 (applies to me very much, or most of the time). The result on each subscale was obtained by summing the estimates of the corresponding items and subsequently categorized into normal, mild, moderate, severe, or extremely severe.

Health-related quality of life. Health-related quality of life (HRQOL) was measured using a validated Chinese version of a short-form 36-item health survey (13). This questionnaire consists of 36 questions, including an eight-domain profile of functional health and well-being scores (physical functioning, role limitation due to physical problems, bodily pain, general health, vitality, social functioning, role limitation due to emotional problems, and mental health). The scores on each parameter are coded, summed, and transformed on a scale from 0 to 100.

Exercise motivation. The Chinese version of behavioral regulation in the exercise questionnaire (14) was adopted to evaluate participants' underlying motivational regulation relating to HIIE and MIIE participation. The C-BREQ-2 comprised 18 items with ratings on a 5-point Likert scale ranging from 0 (not valid for me) to 4 (very accurate for me). It measures amotivation (e.g., "I think exercising is a waste of time"), external (e.g., "I exercise because other people say I should"), introjected (e.g., "I feel guilty when I do not exercise"), identified (e.g., "it is important to me to exercise regularly"), and intrinsic (e.g., "I find exercise a pleasurable activity") regulations of exercise behavior. Scores were calculated based on mean scores across subscale items.

Training protocol. Participants performed 12 weeks of exercise training intervention involving a 3-min warm-up at 4.0 $km.h^{-1}$ followed by 5 (week 1) to 10 (week 12) x 1 min work interval performed at 90% of MAS (HIIE) and 60% of MAS (MIIE) separated by 75 s of active recovery phase. The number of work intervals was increased by one repetition every two weeks of exercise interventions. During the 1-minute work interval, participants continuously ran between two markers set apart to permit the running speed to match either 90% or 60% of MAS (i.e., the distance between the cones varied between participants according to their group, Figure 1). To pace individual speeds, every ten seconds (i.e., 6 times per minute), a sound cue (i.e., whistle blow) was emitted to which participants should be at their cones. No visual or audio entertainment was provided during the interval exercise session.

Statistical analysis. All parameters were presented as mean ± standard deviation (SD) and were analyzed via SPSS (SPSS 26.0; IBM Corporation, Armonk, NY, USA). The normal distribution of the data was checked using the Shapiro–Wilk normality test. A mixed model ANOVA design with the between factor' group' (HIIE vs. MIIE) and repeated factor 'time' (before and after) was used to analyze training session variables (i.e., mental health, HRQOL, and exercise motivation). Bonferroni post hoc test was carried out on significant interactions to examine the location of differences. Homogeneity of variance was determined using Mauchly's test of sphericity, and the degrees of freedom were

adjusted using the Greenhouse–Geisser correction if required. The null hypothesis was rejected at an alpha level of 0.05, and the magnitude of mean differences was interpreted using effect size (ES) calculated using Cohen's d (15), whereby an ES of 0.20 was considered to be minor changes between means, and 0.50 and 0.80 were considered as moderate and large changes, respectively.

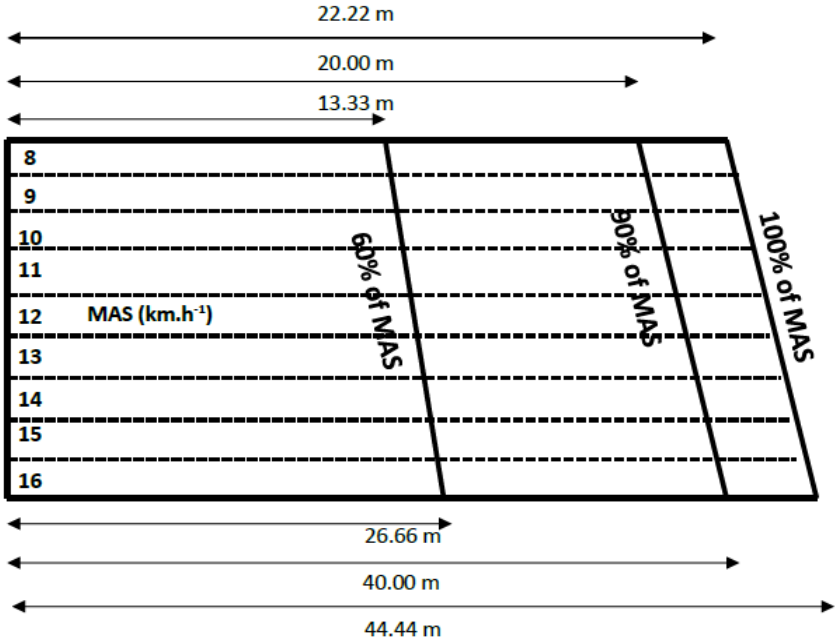

Figure 1. Short track for interval exercise.

RESULTS

Baseline participant characteristics are presented in Table 1. There were no differences across all variables between time (pre-post) for both HIIE and MIIE groups (group by time interaction P=0.08). However, there was a significant main effect for a time in weight (P=0.02), BMI (P=0.04), and estimated $\dot{V}O_{2max}$ (P=0.02) in the HIIE group, as presented in Table 1. Specifically, the HIIE group elicited more remarkable improvement before and after intervention in these variables than the MIIE group (all ES>0.60). In contrast, the MIIE group showed moderate enhancement in estimated $\dot{V}O_{2max}$ from pre- and post-exercise intervention (P=0.04, ES=0.45) and not for other health indices variables (all ES<0.24). Training compliance was 100% for both groups, and no adverse effects were reported.

Table 1. Baseline characteristics of the participants (N=24)

VARIABLES	MIIE (n=12)		HIIE (n=12)	
	Pre	Post	Pre	Post
Age (years)	20.92±1.08	-	20.75±1.29	-
Weight (kg)	60.6±8.2	60.3±8.9	63.3±9.1	61.5±8.7^
Height (m)	168.9±8.5	-	166.3±6.2	-
BMI ($kg \cdot m^2$)	21.6±1.9	21.3±1.8	22.1±1.6	21.1±1.5^
$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	36.7±2.9	39.2±3.2^	36.6±2.7	42.8±2.7^
MAS ($km \cdot h^{-1}$)	5.1±0.1	-	9.1±1.0	-
IPAQ-M (MET-min/week)	451±77	-	446±87	-

Values are reported as mean±standard deviation and effect size (ES); ^: Significant difference between pre-post.

Depression, anxiety, and stress. A mixed model ANOVA showed that there was a significant group by time interaction in depression (P=0.01) and anxiety (P=0.03), but not for stress (P=0.42). Specifically, the HIIE group elicited more remarkable improvement in depression (ES=1.25) and anxiety (ES=1.98) symptoms compared to the MIIE group

following 12 weeks of exercise intervention, as shown in Table 2.

Health-related quality of life. A mixed model ANOVA showed that there was no significant group by-time interaction in all dimensions of HRQOL, but there was a significant main effect for time across all dimensions following a 12-week HIIE intervention as illustrated in Table 3 (all P<0.02, all ES>0.50). Also, there was a significant main effect of time following a 12-week MIIE intervention in the physical role limitations and energy/fatigue dimensions of HRQOL (all P<0.04, all ES>0.30).

Exercise motivation. A mixed model ANOVA showed a significant group-by-time interaction effect in the exercise motivation variables: intrinsic, identified, introjected, external, and amotivation (P<0.001, see Table 4). Specifically, the HIIE group produced more excellent scores in intrinsic (P=0.01, ES=1.19) and identified (P=0.03, ES=0.57) variables compared to the MIIE group following the exercise intervention period. In contrast, the MIIE group produced a more excellent score in extrinsic (P=0.01, ES=1.23) and amotivation variables (P=0.02, ES=0.71) than the HIIE group following the exercise intervention period.

Table 2. Symptoms of stress, anxiety, and depression from DASS-21

Symptoms	HIIE group (n=12)		MIIE group (n=12)	
	Pre	Post	Pre	Post
Stress	11.9±1.7	5.8±2.1	11.3±3.3	6.1±2.1
Anxiety	6.8±0.9	3.1±0.6*	6.7±1.1	6.3±2.2
Depression	8.2±1.4	3.9±0.9*	8.7±1.7	5.3±1.3

Values are reported as mean±standard deviation and effect size (ES); *: Significant difference between groups.

Table 3. Overall dimensions of HRQOL before and after interventions in HIIE and MIIE groups

Dimensions	HIIE group (n=12)		MIIE group (n=12)	
	Pre	Post	Pre	Post
Physical functioning	92.0±5.4	94.3±5.3^	92.5±5	92.9±4.5
Physical role limitations	72.9±16.7	82.8±10.6^	75.00±21.3	79.17±17.9^
General Health	70.8±9.7	75.00±11.2^	68.75±11.3	69.35±10.3
Energy/fatigue	64.6±17.1	77.58±10.6^	65.83±14.1	67.70±14.4^
Social functioning	71.8±14.2	79.17±13.4^	75.00±15.0	76.41±15.1
Emotional role limitations	52 .1±33.1	66.25±24.7^	49.67±33.2	52.12±29.9
Emotional well-being	67.5±15.3	72.1±13.5^	68.00±14.6	69.92±14.0

Values are reported as mean±standard deviation and effect size (ES); ^: Significant difference between pre-post.

Table 4. Exercise motivation variables before and after HIIE and MIIE interventions

Motivations variables	HIIE group (n=12)		MIIE group (n=12)	
	Pre	Post	Pre	Post
Intrinsic	6.9±3.8	11.3±3.1*	6.5±2.9	8.1±2.2
Identified	6.8±2.8	9.3±6.6*	6.6±1.9	6.6±1.1
Introjected	5.4±1.9	6.1±1.9	4.3±1.9	5.5±1.9
External	9.6±4.2	4.8±1.8*	8.8±2.7	7.2±2.1
Amotivation	10.5±5.1	5.6±3.4*	9.7±3.2	7.9±3.1

Values are reported as mean±standard deviation and effect size (ES); *: Significant difference between groups.

DISCUSSION

The present study shows data on mental health, HRQOL, and exercise motivation in a 12-week HIIE and MIIE intervention among physically inactive college students. The key findings from this study are: 1) HIIE group elicited more remarkable improvement in anxiety and depression compared to MIIE group following 12 weeks of exercise intervention, 2) HIIE group produced enhancement in overall HRQOL domains following 12 weeks of exercise intervention but not in MIIE group, and 3) HIIE elicited more excellent scores in two exercise motivation domains, namely, intrinsic and identified but lower scores in external and Amotivation domains compared to MIIE.

In this study, we found a significantly lower score in anxiety and depression domains measured via DASS-21 from pre- to post-exercise intervention in the HIIE group compared to the MIIE group (ES>1.25), indicating a more remarkable improvement in mental health among college students following a 12-week HIIE intervention. Our finding is consistent with previous HIIE-based studies on mental health, showing that HIIE protocol can induce the enhancement of multiple mental health (i.e., anxiety and depression) compared to much lower exercise intensity (e.g., low and moderate) in various populations, including young people (5). Indeed, previous dose-response studies on mental health have shown that high-intensity, rather than moderate-intensity, exercise could provide an optimal stimulus for reducing anxiety and depression symptoms in young people (16). One plausible explanation for the reductions in anxiety and depression favoring the HIIE group in our study may be attributed to the more significant improvements in cardiorespiratory responses following a 12-week HIIE intervention compared to the MIIE intervention. Indeed, previous systematic reviews have reported that mental health improvements following HIIE interventions are mediated by enhancements in cardiorespiratory fitness (17).

We also observed an improvement in the overall domain of HRQOL that consisted of physical functioning, physical role limitations, general health, vitality, social functioning, and emotional state following a 12-week HIIE intervention. In contrast, the MIIE group only shows improvement in physical role limitations and vitality following a 12-week exercise intervention. This finding reveals that a 12-week HIIE intervention can maximize overall improvements across all HRQOL domains compared to the MIIE intervention. This notion is consistent with previous systematic reviews and meta-analyses, which indicated the superiority of HIIE training in promoting the positive impact of HRQOL compared to moderate-intensity exercise training among non-clinical and clinical populations (18). Our finding strengthens this evidence by showing the impact of HIIE training on HRQOL among physically inactive college students. A previous study by Imayama and colleagues (19) reported that greater exercise volume is more effective in improving the HRQOL than low-to-moderate exercise volume. In the present study, despite both HIIE and MIIE consisting of a similar training volume (12 weeks intervention, three times per week, and exercise durations of ~ 24 mins), HIIE training possessed a higher work intensity (90% of MAS) compared to MIIE (60% of MAS). Therefore, it is plausible to suggest that exercise intensity may also facilitate the changes in HRQOL from baseline to post-exercise training rather than exercise volume per se (20).

Regarding exercise motivation, the HIIE group elicited more excellent scores in intrinsic and identified dimensions than the MIIE group following a 12-week exercise intervention (ES=1.19 and ES=0.57, respectively). In contrast, the MIIE group produced more excellent scores in external and demotivation dimensions from pre- to post-exercise intervention than the HIIE group (ES=1.23 and ES=0.71, respectively). This finding reinforces the notion that HIIE may facilitate more significant improvements in the self-determined motivation of physically inactive college students. Our finding is in agreement with previous studies by Alarcón-Gómez and colleagues (21), who revealed that the utilization of HIIE protocol increased self-determined domains of autonomous motivational regulation, namely, intrinsic and identified dimensions following 6 weeks of exercise interventions in Type 1 Diabetes Mellitus patients. According to the self-determination theory (22), individuals with more significant intrinsic goals will usually be influenced by internal factors such as enjoyment and personal satisfaction. Our previous finding with similar exercise intervention and protocol has shown that HIIE produces more remarkable improvement in perception responses, namely, pleasurable feelings and enjoyment responses, following a 12-week exercise intervention in physically inactive college students (9). Given the more excellent work and challenge required when performing HIIE compared to MIIE, we, therefore, reason that the improvement in self-determined motivations within the HIIE group in the current study is likely to account for the sense of accomplishment and success after the completion of HIIE. Indeed, Malik and colleagues (8) have suggested that the challenge posed by the HIIE protocol may lead to more enjoyable feelings due to the intense feelings of success in young people. Based on the current findings, we proposed that HIIE intervention may elicit greater exercise adherence in physically inactive college students because enjoyment and

self-determined motivation correlate with future exercise behavior.

One of the strengths of this present study relates to the study population. Our participants were insufficiently active, which could enhance the transferability of our findings for exercise interventions that are extensively required among college students. Furthermore, given a low level of PA in this cohort, our finding may offer insightful knowledge related to the HIIE prescription (i.e., work intensities) and motivational perspectives that could impact the feasibility of this protocol as a strategy for promoting health benefits. Also, an outdoor-based interval exercise protocol performed by the participants could enhance the ecological validity of this study. Regarding the study limitation, our data may not apply to other exercise modalities (e.g., cycling) because the exercise protocol used the running type of exercise. Also, given that various HIIE protocols have emerged in the available HIIE-based studies, the protocol used in the present study should be considered as only one of many possibilities. Other HIIE protocols (e.g., work interval durations and intensities or different modalities) may generate different perceptual and physiological responses.

CONCLUSION

The present study reveals that a 12-week HIIE intervention shows a more beneficial effect on exercise motivation, mental health, and HRQOL in physically inactive college students than the MIIE intervention. This notion is established based on the more excellent enhancement across all variables following a 12-week HIIE intervention group compared to the MIIE group. These observations may also suggest that work intensity significantly facilitates optimal health benefits (physical and mental) among physically inactive college students. Also, it is plausible to propose that performing the HIIE protocol could encourage better exercise adherence and maintenance, considering an improvement in self-determined motivation towards HIIE when promoting such behavior among college students.

APPLICABLE REMARKS

- HIIE elicited more excellent enhancement in mental health after 12-week interventions compared to MIIE.
- HIIE improved overall health-related quality of life after 12-week interventions compared to MIIE.
- HIIE generated more remarkable improvement in self-determined motivation after 12-week interventions than MIIE.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Ming Chang, Adam A. Malik, Hairul A. Hashim. Acquisition of data: Ming Chang. Analysis and interpretation of data: Ming Chang, Adam A. Malik. Drafting the manuscript: Ming Chang, Adam A. Malik. Critical revision of the manuscript for important intellectual content: Ming Chang, Adam A. Malik. Statistical analysis: Ming Chang, Adam A. Malik. Administrative, technical, and material support: Ming Chang, Adam A. Malik. Study supervision: Adam A. Malik, Hairul A. Hashim.

CONFLICT OF INTEREST

The authors mention no "Conflict of Interest" in this study.

ETHICAL CONSIDERATION

a) informed consent was obtained from each patient included in the study, and (b) The study procedures presented in this study received ethics approval from the Human Research Ethics Committee of Universiti Sains Malaysia (JEPeM Code: USM/JEPeM/22080551).

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ROLE OF THE SPONSOR

There is no funding organization or sponsor for this study.

FINANCIAL DISCLOSURE

There is no financial interest associated with this study.

ARTIFICIAL INTELLIGENCE (AI) USE

As non-native speakers, we use AI to check papers for English spelling and grammatical errors.

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