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The effects of sprint interval training and detraining on aerobic fitness in young adults

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The effects of sprint interval training and detraining on aerobic fitness in young adults

Los efectos del entrenamıento de *sprınt* por ıntervalos y del desentrenamıento en la aptıtud aeróbıca de adultos jóvenes

Os efeitos do treinamento intervalado *sprint* e destreinamento na aptidão aeróbica em jovens adultos

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Abstract: Sprint interval training (SIT) has been known to improve aerobic performance as well as health and fitness markers in non-athletic population. However, there's not enough information about performance when SIT is stopped. The aim of this study was to investigate the alterations in the detraining process of the evolution of adaptive physical fitness caused by short-term sprint interval training. The general design of the study was classified as before SIT, training period, after SIT and detraining period measurements. The subjects (n=26) completed the baseline measurements of the 20-m shuttle run test and then were randomized as training and control groups. The control group continued their daily routine and the training group ran SIT for 4 weeks. The 20-m shuttle run test was applied before and after training, and in the 4th and 8th detraining weeks. After the training period, aerobic performance increased in the training group ($p<0.05$). In addition, aerobic performance increases were maintained for the 4 weeks of detraining ($p<0.05$). But the performance increments disappeared in the 8th detraining week ($p>0.05$). Taking a break from the exercise program for more than 4 weeks in healthy young individuals may cause the positive effects of SIT on maximum oxygen uptake (VO2max) to disappear. SIT participants should not take a break from exercise for more than 4 weeks if they are to maintain aerobic gain.

Keywords: training, aerobic exercises, physical activity, sprinting

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Resumen: Se sabe que el entrenamiento de *sprint* por intervalos (SIT) mejora el desempeño aeróbico, así como los marcadores de salud y aptitud física en la población no atlética. Sin embargo, no existe información suficiente sobre el desempeño cuando se interrumpe el SIT. El objetivo del presente estudio fue investigar las alteraciones en el proceso de desentrenamiento de la evolución de la aptitud física adaptativa causadas por el entrenamiento de *sprint* por intervalos de corta duración. El diseño general del estudio se clasificó como antes del SIT, período de entrenamiento, después del SIT y medidas del período de desentrenamiento. Los

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sujetos (n=26) completaron las mediciones de base de la prueba de carrera de 20 m y después fueron distribuidos aleatoriamente en grupos de entrenamiento y de control. El grupo de control mantuvo su rutina diaria y el grupo de entrenamiento realizó el SIT durante 4 semanas. La prueba de carrera de 20 m fue aplicada antes y después del entrenamiento y en las semanas 4ª y 8ª del desentrenamiento. Después del período de entrenamiento, el desempeño aeróbico aumentó en el grupo de entrenamiento ($p<0.05$). Además, los aumentos del desempeño aeróbico se mantuvieron durante las 4 semanas del desentrenamiento ($p<0.05$). Pero los aumentos de desempeño desaparecieron en la 8ª semana del desentrenamiento ($p>0.05$). Hacer una pausa en el programa de ejercicios por más de 4 semanas en individuos jóvenes saludables puede hacer que los efectos positivos del SIT en el consumo máximo de oxígeno (VO_{2max}) desaparezcan. Los participantes en el SIT no deben hacer una pausa en el ejercicio por más de 4 semanas para mantener la ganancia aeróbica.

Palabras clave: entrenamiento, ejercicios aeróbicos, actividad física, *sprint*

Resumo: O treino intervalado de *sprint* (SIT) melhora o desempenho aeróbico, bem como marcadores de saúde e aptidão física na população não atlética. No entanto, não há informações suficientes sobre o desempenho quando o SIT é interrompido. O objetivo deste estudo foi pesquisar as alterações no processo de destreinamento da evolução da aptidão física adaptativa causadas pelo treinamento intervalado de sprint de curta duração. O desenho geral do estudo foi classificado em pré-SIT, período de treino, pós-SIT, e medidas de período de destreinamento. Os sujeitos (n = 26) completaram as medidas de base do teste de corrida de 20m e foram distribuídos aleatoriamente em grupos de treinamento e controle. O grupo de controle manteve sua rotina diária e o grupo de treinamento realizou o SIT por quatro semanas. O teste de corrida de 20 m foi aplicado antes e após o treinamento e na quarta e oitava semana de destreinamento. Após o período de treinamento, o desempenho aeróbio aumentou no grupo de treinamento ($p < 0,05$). Além disso, os aumentos no desempenho aeróbico foram mantidos durante as quatro semanas de destreinamento ($p < 0,05$), porém, os aumentos no desempenho desapareceram na oitava semana do destreinamento ($p > 0,05$). Pausar o programa de exercícios por mais de quatro semanas em indivíduos jovens saudáveis pode fazer com que os efeitos positivos do SIT no consumo máximo de oxigênio (VO2máx.) desapareçam. Os participantes do SIT não devem pausar o exercício por mais de quatro semanas para manter o ganho aeróbico.

Palavras-clave: treinamento, exercícios aeróbicos, atividade física, *sprint*.

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1. Introduction

There is strong evidence that regular physical activity makes a significant contribution to preventing a wide range of health problems. For cardiovascular and metabolic benefits, in adults are recommended 150 minutes of moderate or 75 minutes of vigorous physical activity per week

(Garber, 2011). Cardiovascular capacity is important not only in health-related factors but also in exercise performance. Maximum oxygen uptake ($VO_{2\,max}$) is an important indicator for determining cardiovascular health. Vo_{2max} can be measured direct or indirect methods like cycling test, cooper test or multistage run test. These VO_{2max} predictive tests showed high correlation with the direct test. It is important that 20 m shuttle run test had 0.86 correlation with direct test. This indirect test can also be used to predict and assess aerobic fitness. Field test results can be obtained by recreational exercisers to easily observe and compare fitness levels (Grant et al.,1995).

In endurance sports, it is expected to have high VO_{2max}. Long-term low and moderate-intensity aerobic exercises have been reported to increase the VO_{2max}. Maintaining a lifelong exercise routine is important. This is true for those who exercise to improve their health and lead a healthy lifestyle. It is also true for those who have been advised to exercise by a physician. However, it may be difficult for some people to maintain moderate or prolonged exercise for lifelong. However, in recent decades, studies have shown that several weeks of high-intensity interval training increases VO_{2max} to a similar extent as longer duration endurance training (Burgomaster et al., 2008; Daussin et al., 2008; Gibala et al., 2006) due to peripheral (Burgomaster et al., 2005; Macpherson et al., 2011; Vollaard et al., 2017) and cardiac (Astorino et al., 2017) adaptations. For individuals who do not have time for long-term exercises (Tomlin & Wenger, 2002), all-out sprint exercises (SIT (Sprint interval training)) are recommended for cardiovascular gains (Boullosa et al., 2022; Tomlin & Wenger, 2002). However, the type, duration and intensity of training with SIT, and the optimal type of training to achieve aerobic gains are unclear (Macpherson et al., 2011). The effect of sprint times, recovery durations, and number of sprints on aerobic capacity have not been demonstrated. Furthermore, how aerobic performance gains are affected during training cessation is not known clearly. In the literature, it has been stated that the performance losses are less in well-trained athletes during the detraining period.

Participants may occasionally need to take a break from training, whether they are exercising for health or as competitive athletes. Common reasons include becoming ill or getting injured. Unfortunately, physical gains from exercise can be reversed by reducing or stopping training (detrained). Decreases in VO_{2max}, cardiac and muscular adaptations, and oxidative enzyme activity have been reported during detraining periods (Mujika & Padilla, 2000). Researchers have shown that following a period of detraining in athletes, sprint intervals can improve physical performance in a short period of time (Clemente et al., 2022; Joo, 2018). One study (Burgomaster et al., 2007) showed that six weeks of SIT resulted in an increase in aerobic and anaerobic enzymes in skeletal muscle. This increase was maintained after a six-week period of detraining. However, this study used longer sprints (repeated 30 s Wingate sprints). At these sprint durations, the effect of the aerobic component is important. We did not find any studies in the literature that have investigated how the increase in aerobic capacity induced by short-term SIT running is affected by cessation of training in young adults. It is important to understand this process as it will show how aerobic capacity is affected in people who interrupt or have to interrupt SIT for different reasons. In addition, it has the potential to guide volunteers by knowing after how many weeks SIT gains are likely to diminish.

Therefore, the aims of this study were: a) to examine the impact of repeated sprint training on aerobic fitness, and b) to investigate the alterations in aerobic fitness during the detraining period. The study hypothesis was that the aerobic gain within weeks provided by the SIT will continue during the detraining period for 8 weeks.

2. Methods

General Design

Figure 1 shows the general study design. The study was designed in three parts: pre-training period, training period and detraining period. Pre-exercise measurements included body weight, height, body fat percent, $VO_{2\ max}$. The participants were randomly divided into two groups: control and experimental. The training group performed the SIT for four weeks, following one week of familiarization. After the training period, the pre-training measurements were repeated. After that, the detraining process was started, which will last for 8 weeks. At the end of the fourth and eighth weeks of the detraining period, the VO_{2max} test was repeated. The subjects in the control group continued their daily routine. They were recreationally active and did not take part in any special exercise.

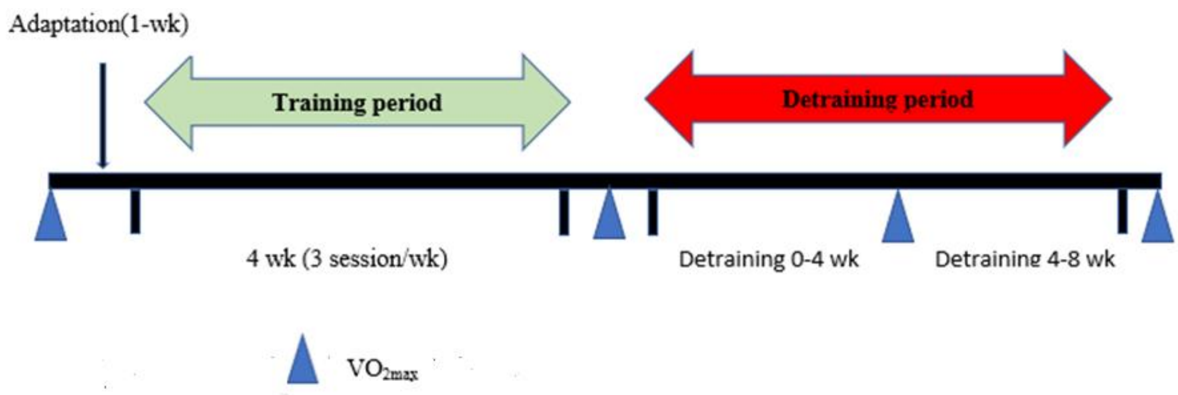

Figure 1. General design of the study in the training group. Source: the authors.

Subjects

A total of 26 students (14 female and 12 male) participated in the study on a voluntary basis. The subjects were active in their leisure time and took part in a variety of physical activities such as tennis, walking and jogging on different days of the week. However, none of the subjects participated in regular exercise or sports training. The descriptive characteristics of the subjects are shown in Table 1. Signed informed consent was obtained from all participants prior to data collection and after the study protocol was reviewed by [Selcuk University Local Ethic Commitment] and approved on [04.03.2019] according to document [24782].

Anthropometric measurements

When the subjects first came to the laboratory, their body weights and heights were measured with a Seca scale. During body weight measurements, care was taken to wear bare feet and light clothes. Skinfold thicknesses were measured with a Holtain skinfold caliper from the biceps, triceps, subscapular and suprailiac regions. Body fat percentage was calculated according to the formula of Durnin and Womersley (Durnin & Womersley, 1974).

20 m shuttle run test

The 20 m shuttle running test, which is an indirect measurement method, was used to determine VO_{2max} for aerobic performance measurements of athletes. The 20 m shuttle run test was observed high correlation with direct VO_{2max} test (Chung et al., 2023; Mendez-Cornejo et al., 2020; Matsuzaka et al., 2004). The test was carried out in an indoor sports hall, on a non-slip surface where the starting and ending points of the participants and the corridors to which they will turn every 20 m are marked. Measurements were made with a sound system announcing the signals and personnel recording the shuttle numbers. It was ensured that the participants understood the test and were verbally encouraged to continue until they were exhausted. The initial speed was 8.5 km/h and increased by 0.5 km/h every minute. The maximal attained speed was accepted as the ending test speed. The number of sprints the athletes ran was noted and the maximal attained speed(km/h) and VO_{2max} were estimated by this formula;

> Estimated VO_{2max}= (Maximum activated speed ×6.65 – 35.8) × 0.95 + 0.182 (Flouris et al., 2005). The authors that developed this formula have demonstrated there was a high correlation between between the 20 m shuttle run test and gas analyser results for VO_{2max}.

Sprint interval training

At least 48 h after completing preliminary measures, a 1-week familiarisation trial consisting of 3 sessions was applied. In the familiarization sessions, the subjects warmed up by 15-minute running, stretched extremities, and running 20 m “all-out” repetitive sprint intervals. At least 48 h after familiarisation week, the sprint training began.

Sprint interval training is designed 3 days a week for 4 weeks. Before starting a training session, a warm-up was applied with jogging and athletic drills for 10 minutes. Each session included 20 m “all-out” runnings and 30-seconds of active recovery between sprints. The starting signal was given by a whistle and the 20 m time was recorded with a digital stopwatch. After each sprint, subjects jogged back to the starting line slowly. In the training, each set was composed of 10 x20 m sprint runs. Five minutes of passive rest was given between sets. The set numbers are increased gradually with training. In the first week 1 set (10x20 m), in the second week 2 sets (2x10x20 m), in the third week 3 sets (3x10x20 m), and in the fourth week 4 sets (4x10x20 m) sprints were run.

The training was applied at the same times of the day (01.00-03.00 pm). During the study, the participants did not engage in regular sports activities other than their usual routines.

Statistical analysis

The normal distribution analysis of the measured variables was applied with the Shapiro-Wilk's test. SPSS 16 (Chicago, USA) was used for statistical analysis. Two-factor (2x4) split plot ANOVA was used for repeated measurements of VO_{2max} and post hoc tests were performed with Bonferroni correction. Factors in VO_{2max} were defined as the group (training and control) and time (pre-training-post-training- 4th week of detraining- 8th week of detraining).

When group interaction was significant for both variables, an unpaired t-test was used to compare results between groups. Paired t-test was used to analyze the group from which the importance of the time factor originated. $p<0.05$ was considered statistically significant.

3. Results

Table 1 shows the descriptive characteristics of both groups. T-test results in independent groups showed that all descriptive variables were similar in both groups ($p>0.05$).

Table 1

General characteristics of the subjects. There were not any significant differences in the descriptive measurements($p>0.05$).

	Control (n=12)	Training (n=14)
Age (year)	20.27±1.01	21.52±1.75
Body weight (kg)	57.91±9.47	61.71± 11.3
Height (cm)	166.36± 5.98	168.3± 7.65
Body fat (%)	21.18± 3.12	22.17± 2.32
Maximal attained speed(km/h)	11.55±1.03	11.54±1.04
VO_{2max} (ml/kg/min)	39.92± 3.96	41.27± 6.71

Source: the authors

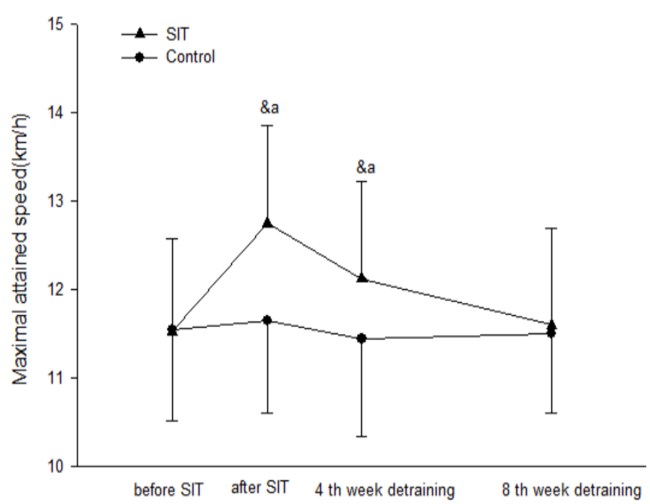

Figure 2. The MAS (maximal attained speed) in 20 m shuttle run test in control and training group. [&] Significant difference in the training group compared to the control group (unpaired t-test, $p<0.05$). [a] significant difference in the training group compared to baseline measurements (One-way ANOVA for repeated measurements, $p<0.05$). Source: the authors.

Figure 2 shows the maximal speed (km/h) values of the participants before, after the SIT period and detraining. The effect of the group factor alone on MAS was insignificant (F=2.42; p=0.12). The effect of the time factor during the training was significant (F=19.17; p<0.001). And the group time interaction was found to be statistically significant (F=11.19; p<0.001). In the training group, MAS was significantly higher than the baseline values in SIT group posttraining (t=3.31; p=0.005) and at the 4th week of detraining (t=2.62; p=0.014). However, the MAS means were similar between pre-training and the 8th week of detraining (t=1.94; p=0.064).

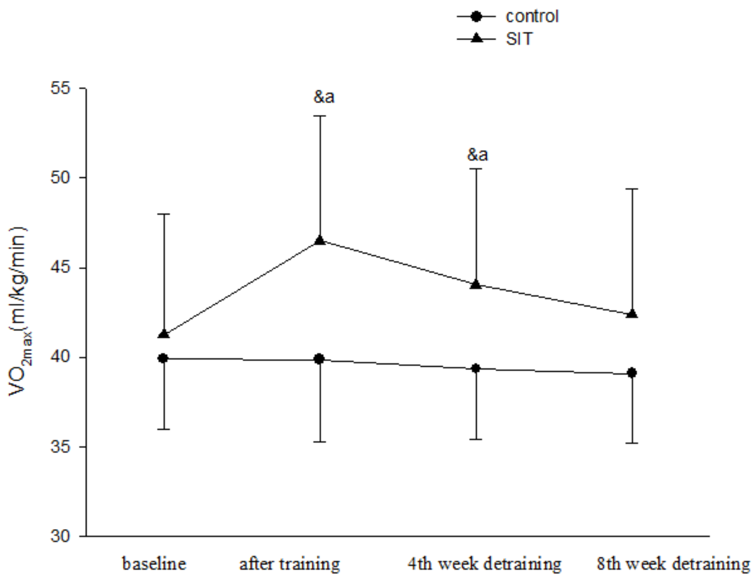

Figure 3. The VO_{2max} during training and detraining period during the study. [&] Significant difference in the training group compared to the control group (unpaired t-test, p<0.05). [a] significant difference in the training group compared to baseline measurements (One-way ANOVA for repeated measurements, p<0.05). Source: the authors.

Figure 3 shows the estimated VO_{2max} values of the participants before, after the SIT period and detraining. The effect of the group factor alone on VO_{2max} was insignificant (F=2.59; p=0.12). The effect of the time factor during the training was significant (F=18.27; p<0.001). And the group time interaction was found to be statistically significant(F=13.92; p<0.001). In the training group, the VO_{2max} was significantly higher than the baseline values after the training (t=3.23; p=0.004) and at the 4th week of detraining (t=2.69; p=0.013) according to the pre-training measurements.However, the VO_{2max} values were similar between pre-training and the 8th week of detraining (t=1.94; p=0.064).

4. Discussion and conclusions

The aim of this study was to investigate the effects of SIT and detraining on aerobic fitness. Two main findings emerged from our study: Firstly, VO_{2max} was significantly increased after four weeks of SIT and, secondly, this progress was maintained during the fourth week of detraining, but it was reduced during the eighth week of detraining.

Previous studies have indicated that high-intensity intervals create a hypoxic environment in skeletal muscle similar to that at high altitude, which in turn increases capillarization, several mitochondria, and mitochondrial enzymes in the muscle. Also, the improvement of the buffer mechanism may increase aerobic capacity (Daussin et al., 2008; Rodas et al., 2000; Sökmen et al., 2018). In this study, the buffer mechanism may explain the increase in aerobic capacity with very short sprint runs. The active recovery between sprints might improve lactate clearance and oxidation by active skeletal muscles.

As high-intensity repetitive sprints stimulate anaerobic metabolism, it is not surprising that the anaerobic performance. Increased mechanical stimulation during maximal sprints may have increased neuromuscular stimulation (Clemente et al., 2022). Changes in neuromuscular components were preserved in the detraining period. In our study, SIT for 4 weeks increased physical fitness and this increase was not affected by 4 weeks of detraining. To our knowledge, there are no prior studies in the literature exploring the aerobic benefits of repetetive sprint interval training during the detraining phase in non-athletes individuals. According to Mujika, VO_{2max} decreases by 6-20% in well-trained athletes during the long detraining period (Mujika & Padilla, 2000). The decrease, which continues for up to 8 weeks, may then remain at the plateau. However, this level is still higher than for sedentary individuals. Aerobic capacity increases in athletes take place over a long period. Short and medium periods of detraining may have different effects on athletes and individuals who do a certain training intensely for only a short time. As far as we know, studies examining the aerobic increases provided by short-term interval training have not focused on the change in aerobic performance in the detraining period. The most original aspect of our study is that it questions how the short-term aerobic increase in recreationally active individuals changes with the cessation of training.

Researchers have shown that after SIT within several weeks, VO_{2max} increased in sedentary individuals (Aslankeser & Balci, 2017; Burgomaster et al., 2005; Gillen & Gibala, 2014; Hood et al., 2011). The researchers stated that this short-term increase was due to peripheral changes in the muscle such as aerobic enzyme activity, and the number of mitochondria (Burgomaster et al., 2005; Gillen & Gibala, 2014). In our study, the short-term increase in aerobic performance returned to the pre-training values in 8th week of detraining, suggesting that peripheral adaptations disappeared between the fourth and eighth detraining weeks.

In the literature, 30-sec Wingate loads are often used as training. We used 20 m repetitive maximal sprint runs. Our findings showed that 4 weeks of sprint interval training provided aerobic development in untrained individuals and there was no decrease in the 4th weeks detraining period. However, it was found that 4 weeks of the detraining period decreased aerobic and anaerobic fitness capacity in trained football players (Clemente et al., 2022). Also, yo-yo test results of the football players decreased after only 2 weeks of detraining (Joo, 2018). In well-trained individuals, the detraining duration for a few weeks causes a decrease in oxidative enzymes and a decrease in aerobic performance. In our study, it was observed that aerobic performance decreased after the 4th week. The decrease in endurance and aerobic performance occurs with the total effect of blood volume, heart rate and cardiac output, ventilatory functions, muscle capillarization, metabolic changes, and cellular changes in muscle (Mujika & Padilla, 2000). It has been stated that 6-week interval training consisting of 30-second sprints increases aerobic and anaerobic metabolism with enzymatic changes in muscle. Although the time-trial performance did not change after the training, aerobic and anaerobic enzyme activity increased in the muscle in that study (Burgomaster et al., 2007). Factors determining performance are complex and effected by physiological and psychological components. Although field tests are less sensitive than muscle biopsy, in our study training-induced aerobic increase persisted for 4 wk of detraining then decreased to baseline values. Although it is an indirect measurement, it was stated that the 20 m shuttle run test showed reliability in evaluating VO_{2max} (Chung et al., 2023; Mendez-Cornejo et al., 2020; Matsuzaka et al., 2004; Flouris et al., 2005).

This study contains some limitations. The VO_{2max} measurement can be made with other methods, such as direct measurement instead of field testing. Also, a higher number of participants will strengthen the study results. One of the limitations of the study is the lack of sprint performance in maximal sprints, including the acceleration and deceleration phases. All sprints were all-out but not analyzed because sprint durations were not recorded. Although the participants were instructed outside of the training sessions and during the quitting process, the change in their physical activity levels was not followed. Thus, future work should include more participants and more detailed measurements.

Recreational exercisers may have to take a break from exercise for different reasons during varying periods. The most common reason for detraining is injuries. It is important to reveal how long the gains are regressed. According to the findings of this study, individuals who apply SIT to increase their fitness level should not interrupt training for more than 4 weeks in order to maintain their increased fitness level.

Note: This study was completed as a master's thesis, was accepted and supported as a project by the Scientific Research Committee of Selcuk University with the title of "The Effect of Sprint Interval Training and Detraining on VO_{2max}".

Contributions: Zubeyde Aslankeser (B-C-D-E) and Cebrail Altinsoy (B-C-E)

A-Financing, **B-**Study design, **C-**Data collection, **D-**Statistical analysis and interpretation of results, **E-**Manuscript preparation

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