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Physiology Sport Approaches: The Role of Walking in Dopamine Stimulation for Transforming Habits and Mental Health

Zulkarnain*
Universitas Islam Negeri Fatmawati Sukarno Bengkulu, INDONESIA

Asnaini
Universitas Islam Negeri Fatmawati Sukarno Bengkulu, INDONESIA

Rini Fitria
Universitas Islam Negeri Fatmawati Sukarno Bengkulu, INDONESIA

Uswatun Hasanah
Universitas Islam Negeri Fatmawati Sukarno Bengkulu, INDONESIA

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Abstract

This study investigates the connection between dopamine stimulation, negative habit management, and mental health improvements through walking. Dopamine, a key neurotransmitter in the brain's reward system, plays a crucial role in motivation, self-control, and emotional regulation. This study aims to evaluate whether walking, as a form of altruistic behavior and social commitment, can stimulate dopamine release that promotes positive emotions, better self-regulation, and the reduction of negative habits. This descriptive quantitative study involved 250 respondents aged 20–50 who regularly walked 3 to 5 times per week. This study measured mental health parameters, including stress, anxiety, and depression, as well as negative habits, including overthinking and poor sleep patterns. The findings demonstrated significant improvements, including reductions in stress (-58%), anxiety (-53%), and depression (-54%), along with increases in happiness (+24%) and calmness (+20%). Behavioral changes were also observed, such as decreased overthinking (-45%) and poor sleep patterns (-46%), alongside enhancements in positive thinking (+27%), social awareness (+28%), and optimism (+29%). These changes suggest an increase in dopamine production associated with regular walking activities. This study highlights that walking is an accessible physical intervention that can enhance psychological well-being, reduce destructive behaviors, and strengthen dopamine-related neurobiological pathways. Additionally, this study contributes to positive psychology and exercise science by providing insights into the role of walking in supporting mental health and building personal resilience.

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INTRODUCTION

Mental health issues, such as stress, depression, and anxiety, are on the rise in modern society (Oikonomou et al., 2024; Tran et al., 2024). They significantly affect the quality of life of millions of people worldwide (Elmer et al., 2020; Meng, 2024). The management of negative behaviors, such as overthinking and irregular sleep patterns, is a major challenge that hinders psychological and social well-being and can exacerbate stress, depression, and anxiety (Ruivo et al., 2024; Torales et al., 2020). According to the World Health Organization (WHO), about 5% of adults worldwide experience depression (WHO, 2024). Data from Statista also reveals that 31% of adults experience stress (Statista, 2024), and an estimated 4% of the global population currently experiences anxiety (WHO, 2023). These problems can be understood by understanding the role of dopamine, a key neurotransmitter in the brain's reward system that regulates motivation, self-control, and emotions (Speranza et al., 2021a; Wise & Robble, 2020a).

Dopamine is important in reinforcing positive behaviors and controlling impulses (Cools, 2008). Higher levels of dopamine activity are known to increase intrinsic motivation, help individuals break bad habits, and adopt healthy lifestyles. Dopaminergic pathways in the brain, such as the mesolimbic and mesocortical systems, are directly involved in the processes of emotion regulation and reinforcement of beneficial habits, making them important targets in neurobiology-based

*** Corresponding author:**
Zulkarnain, Universitas Islam Negeri Fatmawati Sukarno Bengkulu, INDONESIA. zulkarnain@mail.uinfasbengkulu.ac.id

interventions to improve mental health (Baik, 2020; Gao et al., 2022). Given the important role of dopamine in behavioral regulation, lifestyle factors like physical activities have been widely studied in the context of their ability to modulate dopamine levels and improve mental resilience (Ma et al., 2021).

Physical activity, such as walking, has been scientifically proven to increase dopamine release (Matar et al., 2014a; Orcioli-Silva et al., 2021; Rosso et al., 2018), which contributes to better mood, stress reduction, and improved self-control (Radwan et al., 2019; Volkow et al., 2019). Regular walking helps lower the stress levels hormones, such as cortisol while increasing the production of endorphins that work in conjunction with dopamine to provide a relaxing and euphoric effect (Kim et al., 2023; Wise & Robble, 2020b). This synergy is effective in reducing symptoms of depression, anxiety, and prolonged stress (Tsai et al., 2024). Walking improves emotion regulation and strengthens impulse control, allowing individuals to break bad habits like overthinking or irregular sleep patterns more easily (Pulopulos et al., 2020). Walking is a simple yet impactful intervention in supporting overall mental health.

Although the benefits of physical activity on mental health have been widely discussed in various studies (Sharples et al., 2014), research specifically highlighting walking as a simple and accessible intervention that leads to increased dopamine is limited. Several studies have shown that walking has positive effects on dopamine production, including walking causes a release of dopamine that may contribute to changes in habits and motivation (Li et al., 2011), exploring the role of dopamine in Parkinson's disease by walking Gilat et al., (2017) and Matar et al., (2014), walking can decrease stress hormones such as cortisol and increase neurotransmitters such as dopamine (Mengist et al., 2024), and walking causes dopamine function to increase (Chao et al., 2012; Park et al., 2016). However, to the best of the researcher's knowledge, no studies have specifically used exercise physiology approaches to explore the role of walking in dopamine stimulation for habit transformation and mental health. Therefore, this study aims to evaluate whether walking, through dopamine stimulation, can support the cessation of bad habits and improve mental health. This study combines neurobiological and psychosocial perspectives to develop more effective and sustainable physical activity-based interventions.

METHOD

Research Design

This study employed a quantitative descriptive method with a survey approach (Seixas et al., 2017; Withall et al., 2011) to evaluate the relationship between walking, dopamine stimulation, mental health changes, and individual behavioral bad habits. The quantitative descriptive method was chosen to describe phenomena objectively based on respondents' numerical data (Ahmad et al., 2019). This design is also suitable for identifying patterns of relationships between variables without direct intervention from the researcher to provide an accurate picture of the effects of walking on dopamine release and its impact on the habits and psychological state of individuals (Vila et al., 2021; Wild & Schulze, 2020).

Population and Sample

Two hundred fifty respondents were selected based on a stratified random sampling method (Rozikin et al., 2024; Tuan, 2024) to ensure balanced representation based on their age category and physical activity level (Olken & Rotem, 1995). The respondents involved individuals aged 20-50 years who regularly engage in walking activities for 30-60 minutes, 3-5 times per week. These characteristics were chosen because the age range is a productive phase of life where individuals face higher stress levels due to various demands, such as work, family, or studies (Luo & Roth, 2000). The selected age range was also seen as a group capable of participating in walking activities independently and consistently, which is relevant for observing the impact of dopamine release on mental health and habit transformation (Majcher-Maślanka et al., 2017).

Instrument

The research instrument was a structured questionnaire designed to measure three main aspects: frequency of walking activity, dopamine release, and changes in mental health and individual habits (Harsing et al., 2022). The questionnaire was developed based on the research indicators that

included bad habits (overthinking and disturbed sleep patterns) and mental health indicators (happiness, calmness, positive thinking patterns, social connectedness, and optimism). Each item uses a 10-point Likert scale to evaluate the intensity of the respondent's experience. The scores of 1-4 indicate low impact, 5-7 indicate moderate impact, and 8-10 indicate high impact (Wratten et al., 2022). Table 1 summarizes the dimensions, indicators, and related questionnaire items.

Table 1. The Summary of Dimensions, Indicators, and Questionnaire Items

No	Dimension (Aspect)	Indicators	Questionnaire Questions	Number of items
1	Bad habit	1. Overthinking	1,2,3	3
		2. Sleep patterns	4,5,6	3
2	Mental health	1. Happiness	7,8,9	3
		2. Calmness	10,11,12	3
		3. Positive thinking	13,14,15	3
		4. Social connectedness	16,17,18	3
		5. Optimism	19, 20	2

Data collection Procedure

Descriptive analysis provided insight into the relationship between walking frequency, dopamine release, and changes in behavior and mental health. This analysis focused on key indicators, including the percentage of respondents who experienced changes in mental health parameters (happiness, calmness, and optimism) and the reductions of negative behaviors (overthinking and irregular sleep patterns). In addition, averages were used to measure the intensity of change reported by respondents on each indicator.

The percentage calculation provides an overview of the proportion of respondents who experienced an increase or decrease in each indicator using the following formula:

$$Percentage = \frac{Actual\ value}{Total\ value} x\ 100$$

The averages were calculated to summarize the general trend of responses and show the average level of changes respondents experienced. The descriptive statistics helped to identify patterns and trends in the data, providing a thorough understanding of the impact of walking on mental resilience and the reduction of destructive habits. The following is the formula for calculating them:

$$Change\ percentage = \frac{After - Before}{Before} x\ 100$$

By combining percentages and averages, this descriptive analysis highlighted the extent to which changes in respondents' mental health and behavior occurred. It illustrates the influence of walking on emotional well-being and habit transformation. Figure 1 illustrates the research procedure in this study.

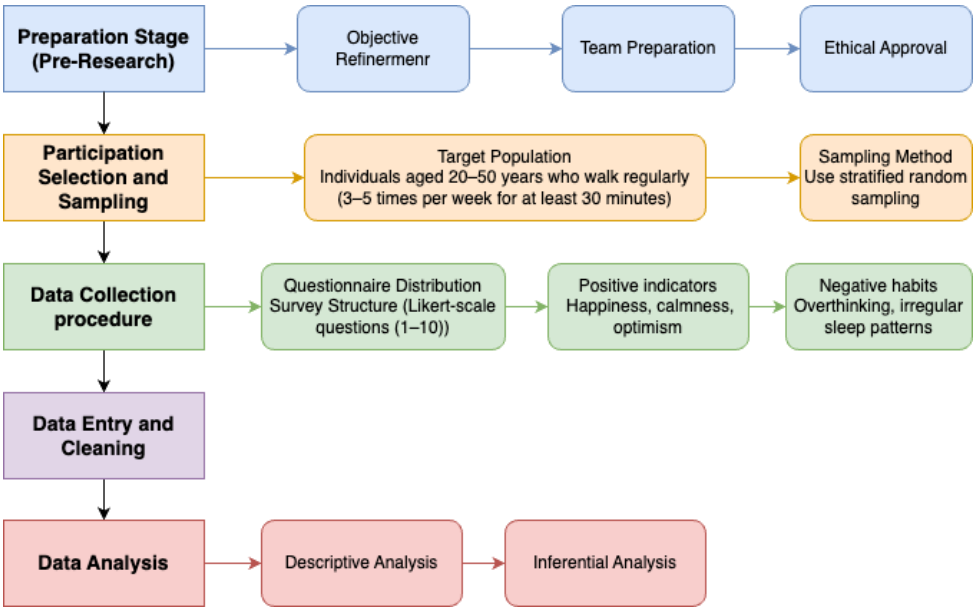

Figure 1. Research Procedure

RESULTS AND DISCUSSION

Results

The result shows that walking has a positive connection with improved feelings associated with the release of dopamine and the decline of destructive behavior in respondents, as shown in Table 2 and Figure 2.

Table 2. The Influence of Walking towards Mental Health

Mental Health Indicators	Before Walking (%)	After Walking (%)	Change (%)
Stress	68%	10%	-58%
Worried	65%	12%	-53%
Depression	62%	8%	-54%
Happy	75%	99%	+24%
Clam	78%	98%	+20%

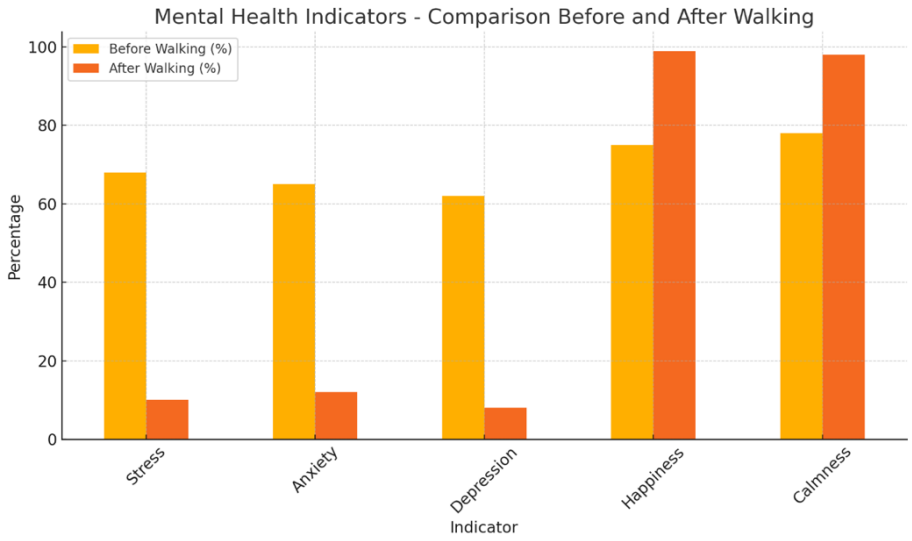

Figure 2. The Influence of Walking towards Mental Health

This study also shows a significant transformation in respondents' behavior, with the decline of negative characteristics, such as overthinking and patterns of sleep, and improvement of positive characteristics, like positive thinking, social connectedness, and optimism. The data is shown in Table 3 and Figure 3.

Table 3. The Influence of Walking towards Behavioral Change

Mental Health Indicators	Before Walking (%)	After Walking (%)	Change (%)
Behavior	60%	15%	-45%
Overthinking	58%	12%	-46%
Sleep patterns bad	72%	99%	+27%
Positive thinking	71%	99%	+28%
Social Connectedness	70%	99%	+29%

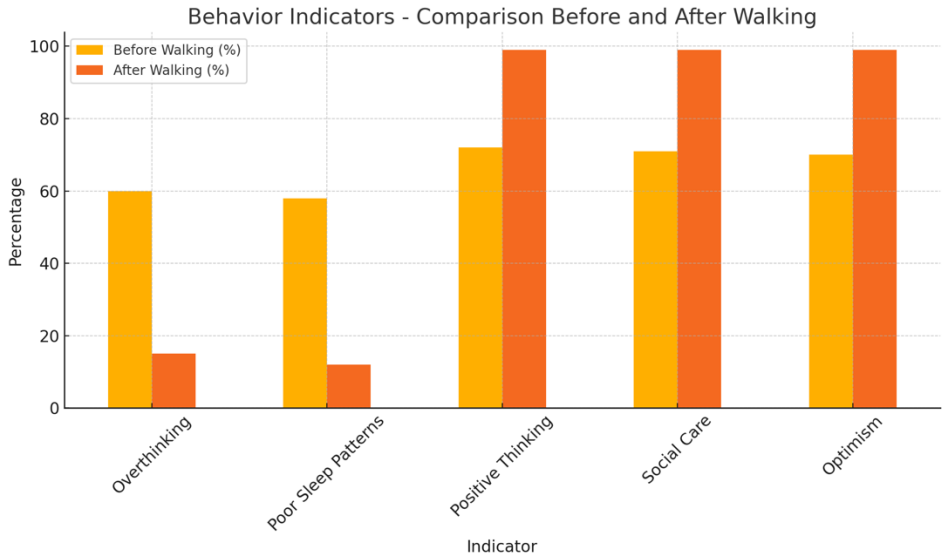

Figure 3. The Influence of Walk towards Behavioral Change

Discussion

The Relationship between Walking and Dopamine Stimulation

The study shows that 250 respondents who practiced walking on foot experienced a significant improvement in positive feelings, with 99% reporting happiness and 98% reporting calmness, as illustrated in Table 1, which highlights the enhancement of positive emotions after walking practice. This improvement in positive feelings correlates with the stimulation of the dopaminergic reward system, as observed in studies related to motivation and behavioral control (Martel & Gatti, 2020). Corkrum suggests walking serves as an intrinsic stimulus reinforcer that stimulates dopamine release by fostering feelings of meaning and social attachment (Corkrum et al., 2020a). This study showed that physical activity involving social commitment can improve psychological well-being and reduce symptoms of anxiety and stress. However, although this study's findings align with Corkrum et al.'s results, the focus of this study extends to the regulation of individual emotions through independent walking routines without direct social interaction. This finding is in contrast to the study of Westgarth et al. (2022), which emphasized social factors, such as the presence of walking companions (e.g., pets), as significant factors in providing emotional benefits. In addition, Li et al. (2011) showed that walking in a natural environment can increase relaxation and dopamine release due to exposure to a calming atmosphere. However, this study

focused more on the intrinsic neurobiological effects of walking without relying on a specific environmental context.

This comparison suggests that although social and environmental elements may enhance the benefits of walking, the core mechanisms of dopamine stimulation remain significant even in minimalist walking routines. This claim supports the idea that self-directed physical activity is sufficient to trigger dopaminergic responses, which contribute to mood regulation and increased resilience.

The Formation of Dopamine after Walking

Dopamine is produced during the walking through track mesolimbic to create a sense of happiness and satisfaction (Sturges & Bailey, 2023; Westgarth et al., 2017). Dopamine activation receptor triggers biochemistry track that enhances neuronal plasticity, regulates the heart's atmosphere, and reduces stress (Reynolds et al., 2023). Research conducted by Köhncke suggests that physical activity such as walking can increase dopamine levels, amplifying the positive response to activity through complex biochemical mechanisms (Köhncke et al., 2018). Furthermore, walking increases the brain's need for neurotransmitters, such as tyrosine, which supports dopamine production and lowers levels of stress hormones or cortisol (Douma & de Kloet, 2020). Increased physical activity correlated with reduced cortisol levels and increased dopamine synthesis in the brain's reward circuitry (Gupta et al., 2024). Previous studies, focused on the role of dopamine in improving motor function in Parkinson's patients due to walking (Gilat et al., 2017 ; Matar et al., 2014b). However, this study is different as it examines the effects of walking on a healthy non-clinical population, focusing on habit transformation and mental well-being. Unlike the study by Westgarth which attributed happiness with walking to social factors, this study shows that dopamine release from a self-directed physical activity such as walking can trigger increased psychological resilience without direct social engagement (Westgarth et al., 2022).

During walking, neuronal activity increases, which stimulates the enzyme tyrosine hydroxylase to convert the amino acid tyrosine to L-DOPA. Furthermore, L-DOPA is converted to dopamine by the enzyme DOPA decarboxylase (Koblinger et al., 2014; Novotna et al., 2013). Chemistry reaction: Tyrosine → (tyrosine hydroxylase) → L-DOPA → (DOPA decarboxylase) → Dopamine

Dopamine is produced and saved in vesicle synaptic at the end of dopaminergic neuron axons. When walking, the release of dopamine increases the gap between two neurons (Vidyadhara et al., 2023). The structure of dopamine is $C_8H_{11}NO_2$.

HO OH
\ /
C6H4-CH2-CH2-NH2

In its 3D structure, the hydroxyl group (-OH) is positioned within the same plane as the benzene ring, while the ethylamine side chain ($-CH_2-CH_2-NH_2$) extends outward from this plane. The structure of dopamine enables it to bind specifically to dopamine receptors (D1-D5) in the brain and body. The amino group ($-NH_2$) interacts with the active site of the receptors, while the benzene ring and hydroxyl group influence the strength and specificity of the bond (Speranza et al., 2021b).

The released dopamine is bound with the receptor dopamine in post-synaptic neurons, such as D1-like (D1, D5) and D2-like (D2, D3, D4). Activation receptors trigger a series of track biochemistry in neurons, including the cAMP pathway for D1-like receptors (increases neuron activity) and the Inhibition cAMP pathway for D2-like receptors (reduces inhibition of neurons) (Sagheddu et al., 2023).

Chemical Reactions in Receptors Dopamine on D1 Receptor (Mignini et al., 2010) increases adenylate cyclase enzyme activity, and produces improvement cAMP. The reaction chemistry is as follows:

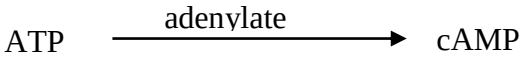

Figure 4. The cAMP formation Reaction

cAMP activates protein kinase A (PKA) regulates gene expression and increases neuronal plasticity. It produces long-lasting happiness.

The D2 receptor reduces cAMP activity, stabilizing neuron activity to prevent overstimulation and providing a calming effect. Dopamine in the nucleus accumbens generates feelings of reward or satisfaction (Lee et al., 2021). This pathway is known as the mesolimbic dopamine pathway. Repetitive activation through activities like walking strengthens this response, creating a positive association with the activity. Dopamine enhances function in the prefrontal cortex, involving motivation, self-control, and problem-solving, fostering a sense of accomplishment and happiness (Corkrum et al., 2020b).

Additionally, dopamine suppresses cortisol release, a hormone related to stress, through a negative feedback mechanism in the hypothalamus. Walking improves blood flow to the brain, supplying more oxygen and nutrients essential for dopamine synthesis. Physical activity also increases the production of brain-derived neurotrophic factor (BDNF), which supports the survival and function of dopaminergic neurons (Maletz et al., 2022).

Implications

The study showed significant improvements of mental health in 250 respondents who practiced regular walking. Respondents reported decreased stress, depression, and anxiety and improved psychological well-being. The practice of walking as a form of physical activity intervention allows individuals to feel a deeper sense of meaning in life and serenity, which correlates with decreased symptoms of depression and anxiety (Bull et al., 2020). These findings support the concept of a "positive spiral" where positive emotions continue to drive dopamine release, strengthen self-control, and improve mental health (Ambrosi & Lerner, 2022; Garland et al., 2010). This study offers both practical and theoretical implications in the field of sports and psychology. The findings suggest that walking can serve as a simple yet effective intervention to enhance psychological well-being and reduce unhealthy habits, such as overthinking and sleep disturbances. From a practical standpoint, lifestyle promotion programs can leverage these findings to improve the quality of life within communities. Additionally, the study expands the understanding of the neurobiological pathways of dopamine and its role in emotional regulation and the formation of positive habits. Furthermore, these results can serve as a foundation for health policies that promote accessible light physical activity across different social groups.

Research Contribution

This study contributes to expanding the understanding of the role of dopamine in light physical activities, such as walking. The findings address a research gap that previously focused more on high-intensity exercise than simple physical activities. This study contributes to the scientific literature by filling the gap in studies that predominantly emphasize high-intensity workouts. Furthermore, the study reinforces that walking can reduce destructive habits and foster positive habits without requiring direct social interaction. It is a relevant option for populations with limited access to fitness resources.

Limitations

This study's limitation lies in the subjective data, which relies on respondents' self-report, which is prone to social bias. In addition, other external variables, such as physical activity intensity and social support, have not been measured in detail. Further research is recommended to use neuroimaging approaches to verify biological changes and involve a more diverse population in age and culture to understand the impact of walking in different social contexts.

Suggestions

Future research should utilize neuroimaging methods to objectively and comprehensively verify changes in dopamine activity. This technology will strengthen empirical evidence regarding the neurobiological mechanisms underlying the effects of walking on mental health. In addition, diverse populations in terms of age, cultural background, and physical activity levels should be included to test the generalizability of the research findings. Further studies can also consider various environmental settings, such as urban, rural, and natural areas, to explore the influence of social and environmental contexts on the effectiveness of walking activities. Research on the duration and intensity of walking is also essential to determine how parameter variations affect dopamine release and promote positive behavioral changes. Thus, the findings can provide a more comprehensive guide for developing health promotion programs based on light physical activity.

CONCLUSION

This study reveals a significant connection between dopamine stimulation, bad habit management, and improved mental health through walking. The results showed that regular walking stimulates the release of dopamine, a neurotransmitter that plays a role in motivation, self-control, and emotion regulation. This light physical activity was shown to improve mental health by lowering levels of stress, anxiety, and depression, as well as reducing bad habits such as overthinking and disturbed sleep patterns. Further development could include studies on the effect of walking intensity and duration on dopamine release and its implementation in various social contexts, such as urban and rural environments. The results of this study have potential applications in public health promotion programs to encourage accessible and affordable active lifestyles. This study contributes to the development of positive psychology and exercise science by providing empirical evidence on the benefits of walking for mental health and positive habit formation. Light physical activity-based programs can be a practical solution to support mental health and improve people's quality of life.

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AUTHOR CONTRIBUTION STATEMENT

Z.Z primarily developed the conceptualization and methodology of the study. Z.Z. also led in software development, formal analysis, data curation, original draft preparation, visualization, supervision, and project administration. Validation and investigation were collaboratively carried out by Z.Z., A.A., R.F., and U.H., ensuring the accuracy and reliability of the findings. The responsibility for securing funding was jointly undertaken by Z.Z., A.A., R.F., and U.H. Additionally, Z.Z. managed the review and editing process of the manuscript. All authors have thoroughly reviewed and approved the final version of the manuscript for publication.

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