ORIGINAL ARTICLE

# Sprint performance adaptations through different warm up stretching approaches

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## ABSTRACT

Background and Aim. Stretching is a crucial component of athletic warm-up routines, influencing flexibility and performance. Static stretching (SS) is commonly used to improve range of motion, whereas dynamic stretching (DS) is often preferred for enhancing explosive movements. The comparative effects of these stretching techniques on sprint performance across multiple distances remain a subject of interest. Materials and Methods. Forty male football players (18–23 years) from SRM Institute of Science and Technology were randomly assigned to a Static Stretching Group (SSG) or a Dynamic Stretching Group (DSG) (n = 20 each). Both groups completed a six-week stretching routine performed before sprint training, five days per week. Sprint times over 10 m, 20 m, 30 m, 40 m, and 50 m were recorded before and after the intervention. A mixed-design ANOVA was used to assess group × time interaction effects, supported by effect sizes and 95% confidence intervals. Results. Both groups showed statistically significant improvements in sprint times after six weeks. However, the DSG demonstrated comparatively greater gains, particularly in the mid-to-long sprint distances (30–50 m), where moderate to strong interaction effects were observed (partial $\eta^2 = 0.21$–$0.33$). Improvements in the SSG were smaller in magnitude, reflecting modest but meaningful performance changes. Correlation analyses indicated strong relationships among sprint distances, while anthropometric variables showed minimal association with sprint outcomes. Conclusions. Dynamic stretching appeared to provide greater short-term benefits for sprint performance compared to static stretching, especially during mid-sprint and longer sprint phases. Although the findings are encouraging, they should be interpreted cautiously due to study limitations such as sample size and intervention duration. Incorporating dynamic stretching into warm-up routines may be a practical strategy for athletes, but further research with larger and more diverse samples is recommended.
**Keywords**: Performance analysis, Sprinting, Static stretching, Dynamic stretching, Warm-up, Football players.

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## INTRODUCTION

Football requires repeated high-intensity sprinting, acceleration, and rapid changes of direction, making sprint performance a key determinant of successful play (Lago et al., 2024; Kalinowski et al., 2021; Maciel et al., 2024). Acceleration and maintaining a high velocity at short distances depend on such components as elasticity of muscles, proper coordination, and neuromuscular conditioning (Nowak et al., 2025). In general, athletes engage in different stretching exercises during warm-ups to increase their flexibility, decrease muscular stiffness, and prepare for an intense activity (Samson et al., 2012; McMillian et al., 2006). Among different types of stretching exercises used in a warm-up routine, static stretching involves holding the muscles in elongated positions for a certain period, while dynamic stretching implies sport-specific movements aimed at activating muscles and increasing the core body temperature. There is some evidence that DS exercises may lead to better performance gains in sprints compared to SS exercises, mainly because of increased preparedness for movement execution (Takeuchi et al., 2024; Hsu et al., 2021). At the same time, extended SS exercises conducted right before starting a sprint exercise can negatively affect the athlete's ability to produce strength in sprinting (Stankovic et al., 2023; Freitas et al., 2023). Moreover, dynamic stretching is known to be positively associated with improved acceleration, coordination, and movement efficiency, while static stretching can be beneficial for achieving flexibility and preventing injuries in the long run (Loughran et al., 2017; Ferger & Moritz, 2017; Takeuchi et al., 2022). However, the effects of dynamic stretching and static stretching on the effectiveness of sprint exercises have not been sufficiently clear yet. In particular, the findings have been controversial, especially as regards the effect on performance at various sprint distances and in football conditions (Alkabi et al., 2020; Alizadeh Ebadi & Çetin, 2018). Anthropometric characteristics such as height, weight, body mass index (BMI), and muscle composition may also influence sprint performance (Woodhouse et al., 2021; Hammami et al., 2023). While DS has been suggested to positively influence movement coordination and sprint-related mechanics (Avloniti et al., 2016), limited research has examined the interaction between stretching protocols and sprint performance specifically among collegiate football players.

### *Aim of the study*

The current study aimed to determine the effects of six weeks of static and dynamic stretching exercises on sprint performance over 10 m, 20 m, 30 m, 40 m, and 50 m distances in male collegiate football players. It was hypothesized that dynamic stretching would produce greater improvements in sprint performance compared to static stretching.

## MATERIAL AND METHODS

### *Study participants*

Forty male collegiate football players (aged 18–23 years) from SRM Institute of Science and Technology voluntarily participated in this study. All participants had a minimum of two years of structured football training. Using a computer-generated randomization process, the players were assigned to either the Static Stretching Group (SSG; n = 20) or the Dynamic Stretching Group (DSG; n = 20). Allocation was performed by an independent investigator using sealed group assignments to minimize selection bias. All participants were clearly briefed on the aims and procedures of the study, and written informed consent was obtained from each individual prior to the commencement of data collection.

### *Study design*

A pre-test/post-test experimental design was used to examine the effects of static and dynamic stretching on sprint performance and body composition. During the pre-test, sprint times were recorded over 10m, 20m, 30m, 40m, and 50m distances. Body weight and BMI were also assessed. The training intervention spanned six weeks. Both groups performed their respective stretching routines before sprint training sessions, conducted five days per week.

*Static Stretching Group (SSG)*
Engaged in static stretching exercises, holding muscle elongation positions for fixed durations.

*Dynamic Stretching Group (DSG)*
Performed dynamic movements such as leg swings, lunges, and high knees to activate major muscle groups.

Each stretching session lasted approximately 15 minutes, followed by sprint drills based on weekly progression. Post-testing was conducted at the end of six weeks using the same parameters to identify improvements in sprint performance and body composition. To minimize the variations, tests were performed during similar hours of the day and under identical environmental conditions. Subjects were informed to avoid any rigorous exercises before the test sessions. However, certain factors that could influence the outcome such as sleep patterns, nutrition, fatigue level, recovery process, psychological preparedness, and any other physical exercise aside from the interventions were not considered during this experiment.

Table 1. Weekly training schedule for SSG and DSG.

| Week | Day | SSG (Static Stretching) | DSG (Dynamic Stretching) | Sprint training | Repetitions & intensity |
|---|---|---|---|---|---|
| 1–6 | Monday | Quadriceps Stretch, Hamstring Stretch, Calf Stretch, Hip Flexor Stretch, Groin Stretch | Leg Swings (Front & Side), Walking Lunges, High Knees, Butt Kicks | 10m | Week 1–2: 4 reps (80%)<br>Week 3–4: 6 reps (85%)<br>Week 5–6: 8 reps (90%) |
| | Tuesday | Hamstring Stretch, Glute Stretch, Shoulder Stretch, Triceps Stretch | Side Lunges, Arm Swings, Skipping, Knee Hugs | 20m | Week 1–2: 4 reps (80%)<br>Week 3–4: 6 reps (85%)<br>Week 5–6: 8 reps (90%) |
| | Wednesday | Seated Hamstring Stretch, Butterfly Stretch, Arm Across Chest, Neck Stretch | Carioca Drill, High Skips, Bounding, Torso Twists | 30m | Week 1–2: 4 reps (80%)<br>Week 3–4: 6 reps (85%)<br>Week 5–6: 8 reps (90%) |
| | Thursday | Hip Adductor Stretch, Lat Stretch, Shoulder Stretch, Ankle Stretch | Toy Soldiers, Quick Feet, Hip Circles, Knee Drives | 40m | Week 1–2: 4 reps (80%)<br>Week 3–4: 6 reps (85%)<br>Week 5–6: 8 reps (90%) |
| | Friday | Calf Stretch, Cobra Stretch, Wrist Stretch, Groin Stretch | Lateral Shuffles, A-Skips, Backward Runs, Arm Circles | 50m | Week 1–2: 4 reps (80%)<br>Week 3–4: 6 reps (85%)<br>Week 5–6: 8 reps (90%) |

### ***Statistical analysis***

Data were analysed using a mixed-design ANOVA to examine the group × time interaction effect between the Static Stretching Group and Dynamic Stretching Group across pre- and post-test assessments. Where baseline differences were detected, ANOVA was applied with pre-test values as covariates. Assumptions of normality, homogeneity of variance, and sphericity were verified prior to analysis. To control the risk of Type I error arising from multiple comparisons, appropriate multiplicity adjustments were applied. Effect sizes were reported using Hedges' g for pairwise comparisons and partial $\eta^2$ for interaction effects. Additionally, 95% confidence intervals (CIs) were provided for all primary outcome measures to improve the precision and interpretability of the findings. Statistical significance was set at $p < .05$. Post hoc power analysis showed adequate power to identify medium and large interaction effects. Nonetheless, the small sample size may have reduced precision and led to biased overestimation of effect sizes.

## RESULTS

The study examined the impact of static and dynamic stretching on sprint performance over different distances. Both stretching methods led to significant improvements, with dynamic stretching showing greater benefits. Statistical analyses, including paired and independent t-tests, confirmed meaningful reductions in sprint times.

Table 2. Within-Group Changes (Pre–Post) – Static Stretching Group (SSG).

| Distance (m) | Pre-test (s) | Post-test (s) | Mean Δ (95% CI) | Hedges' g | *p*-Value (time) |
|---|---|---|---|---|---|
| 10 m | 1.92 ± 0.33 | 1.78 ± 0.42 | –0.14 (–0.20 to –0.07) | 0.34 | .021* |
| 20 m | 3.36 ± 0.34 | 3.22 ± 0.39 | –0.14 (–0.21 to –0.08) | 0.39 | .017* |
| 30 m | 4.61 ± 0.34 | 4.48 ± 0.38 | –0.13 (–0.19 to –0.07) | 0.35 | .012* |
| 40 m | 5.86 ± 0.38 | 5.72 ± 0.40 | –0.14 (–0.22 to –0.06) | 0.40 | .008* |
| 50 m | 7.05 ± 0.48 | 6.90 ± 0.50 | –0.15 (–0.24 to –0.07) | 0.43 | .005* |

The static stretching group demonstrated small but statistically significant improvements across all sprint distances (10–50 m), with mean reductions ranging from –0.13 to –0.15 seconds. The effect sizes (Hedges' g = 0.34–0.43) indicate small improvements, suggesting that static stretching had a measurable but modest influence on sprint performance. The 95% confidence intervals consistently show negative values, confirming that the improvements were real and not due to chance. Overall, while static stretching produced beneficial changes, the magnitude of improvement remained limited compared to dynamic stretching.

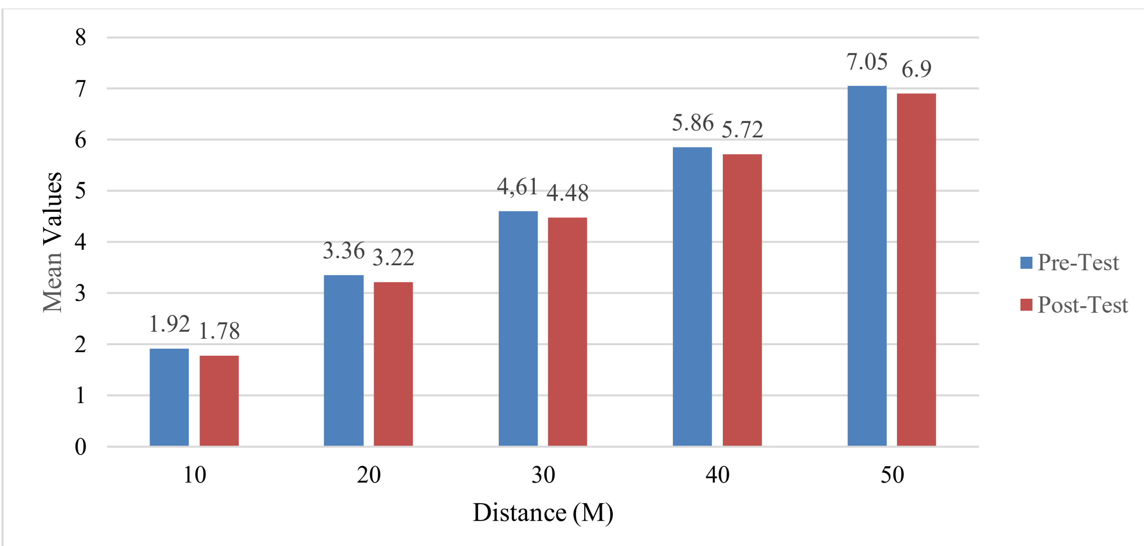


Figure 1. Mean Sprint Times for Static Stretching Group (SSG).

Table 3. Within-Group Changes (Pre–Post) – Dynamic Stretching Group (DSG)

| Distance (m) | Pre-test (s) | Post-test (s) | Mean Δ (95% CI) | Hedges' g | *p*-Value (time) |
|---|---|---|---|---|---|
| 10 m | 1.98 ± 0.34 | 1.86 ± 0.36 | –0.12 (–0.18 to –0.06) | 0.33 | .004* |
| 20 m | 3.39 ± 0.34 | 3.21 ± 0.31 | –0.18 (–0.25 to –0.11) | 0.51 | .002* |
| 30 m | 4.65 ± 0.35 | 4.39 ± 0.32 | –0.26 (–0.33 to –0.19) | 0.71 | <.001* |
| 40 m | 5.96 ± 0.42 | 5.68 ± 0.38 | –0.28 (–0.37 to –0.18) | 0.65 | <.001* |
| 50 m | 7.21 ± 0.49 | 6.98 ± 0.44 | –0.23 (–0.32 to –0.15) | 0.48 | <.001* |

 

The dynamic stretching group showed greater and more consistent improvements in sprint times across all distances. Reductions ranged from –0.12 to –0.28 seconds, with the largest decreases observed in the 30 m and 40 m distances (–0.26 and –0.28 seconds). Effect sizes ranged from 0.33 to 0.71, indicating small to large effects, reflecting a stronger training impact than static stretching. The very narrow and negative 95% CI ranges, along with highly significant p-values ($p$ < .001 for 30–50 m), confirm that dynamic stretching produced substantial and reliable enhancements in sprint performance.

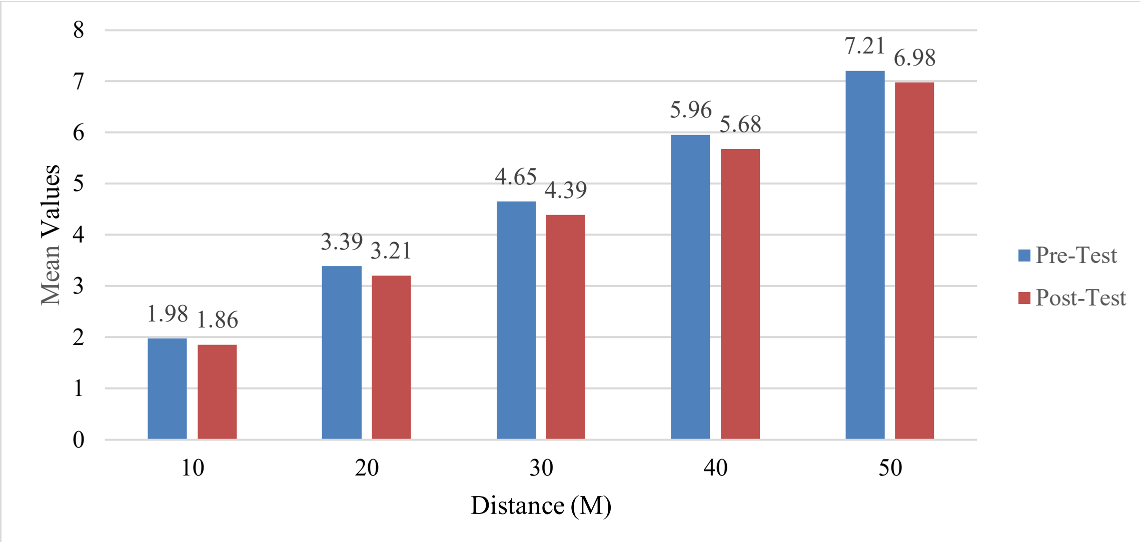


Figure 2. Mean Sprint Times for Dynamic Stretching Group (DSG).

Table 4. Between-group comparison (Mixed ANOVA – Group × Time interaction).

| Distance (m) | F-value | *p*-Value | Partial η² | 95% CI (η²) | Interpretation |
|---|---|---|---|---|---|
| 10 m | 4.82 | <.05* | 0.12 | 0.02 to 0.24 | DSG improved significantly more |
| 20 m | 7.96 | <.01* | 0.19 | 0.08 to 0.32 | Moderate interaction |
| 30 m | 15.42 | <.001* | 0.33 | 0.18 to 0.46 | Strong advantage for DSG |
| 40 m | 13.87 | <.001* | 0.30 | 0.15 to 0.44 | Strong interaction |
| 50 m | 8.61 | <.01* | 0.21 | 0.09 to 0.34 | DSG superior |

The mixed ANOVA results presented in Table 4 suggest progressive group × time interaction effects across all sprint distances, favouring the Dynamic Stretching Group (DSG). At 10 m, a significant interaction (F = 4.82, $p < .05$, partial $\eta^2 = 0.12$) shows that DSG achieved greater early-acceleration improvements than SSG. The interaction strengthened at 20 m (F = 7.96, $p < .01$, partial $\eta^2 = 0.19$), suggesting that dynamic stretching provided a more meaningful enhancement during the transition phase of sprinting. The most pronounced effect occurred at 30 m, where the interaction reached its peak (F = 15.42, $p < .001$, partial $\eta^2 = 0.33$), indicating a substantial performance advantage for DSG during mid-sprint velocity development. Similarly, strong interactions were observed at 40 m (F = 13.87, $p < .001$, partial $\eta^2 = 0.30$), reinforcing the superiority of dynamic stretching in sustaining speed over longer distances. Lastly, at 50 m, the interaction remained significant (F = 8.61, $p < .01$, partial $\eta^2 = 0.21$), confirming that DSG consistently outperformed SSG across the complete sprint profile.

It was observed that there were highly positive correlations between sprint distances in both groups, showing consistency in sprinting performance during acceleration and maximal sprinting phases. However, anthropometric factors such as height, weight, and body mass index showed poor correlations with sprint performances (Table 5 & 6), suggesting that they have little bearing on the sprinting ability of athletes at the current level. Due to the expected high degree of correlation between different sprint distances, correlation findings could be considered as additional information to the study objective.

Table 5. Pearson correlation coefficients among study variables static stretching group.

| Variables | Age | Weight | Height | BMI | 10M | 20M | 30M | 40M | 50M |
|---|---|---|---|---|---|---|---|---|---|
| Age | 1 | .107 | .503* | .428 | -.246 | -.292 | -.324 | -.310 | -.274 |
| Weight | .107 | 1 | .499* | -.127 | -.092 | -.203 | -.209 | -.042 | -.108 |
| Height | .503* | .499* | 1 | .773* | -.027 | -.084 | -.105 | -.015 | -.045 |
| BMI | .428 | -.127 | .773* | 1 | .019 | .041 | .025 | .017 | .024 |
| 10M | -.246 | -.092 | -.027 | .019 | 1 | .977* | .958* | .952* | .924* |
| 20M | -.292 | -.203 | -.084 | .041 | .977* | 1 | .978* | .963* | .922* |
| 30M | -.324 | -.209 | -.105 | .025 | .958* | .978* | 1 | .970* | .943* |
| 40M | -.310 | -.042 | -.015 | .017 | .952* | .963* | .970* | 1 | .963* |
| 50M | -.274 | -.108 | -.045 | .024 | .924* | .922* | .943* | .963* | 1 |

*Note. *Correlation is significant at the .05 level (2-tailed).*

Table 6. Pearson correlation coefficients between variables dynamic stretching.

| Variables | Age | Weight | Height | BMI | 10M | 20M | 30M | 40M | 50M |
|---|---|---|---|---|---|---|---|---|---|
| Age | 1 | .025 | .534* | .560* | -.273 | -.275 | -.283 | -.315 | -.278 |
| Weight | .025 | 1 | .428 | -.167 | -.177 | -.222 | -.279 | -.198 | -.144 |
| Height | .534* | .428 | 1 | .818* | -.072 | -.112 | -.202 | -.116 | -.016 |
| BMI | .560* | -.167 | .818* | 1 | .029 | .020 | -.050 | .007 | .077 |
| 10M | -.273 | -.177 | -.072 | .029 | 1 | .963* | .880* | .922* | .912* |
| 20M | -.275 | -.222 | -.112 | .020 | .963* | 1 | .889* | .957* | .908* |
| 30M | -.283 | -.279 | -.202 | -.050 | .880* | .889* | 1 | .913* | .901* |
| 40M | -.315 | -.198 | -.116 | .007 | .922* | .957* | .913* | 1 | .938* |
| 50M | -.278 | -.144 | -.016 | .077 | .912* | .908* | .901* | .938* | 1 |

*Note. *Correlation is significant at the .05 level (2-tailed).*

## DISCUSSIONS

The findings of this study suggest that both static and dynamic stretching may contribute to short-term improvements in sprint performance among male college-level football players, with dynamic stretching showing comparatively greater benefits, particularly over longer distances. While the results generally align with earlier research indicating that dynamic stretching can enhance muscle activation, neuromuscular readiness, and overall sprint mechanics (Behm et al., 2016; McMillian et al., 2006), these interpretations should be made cautiously. The stronger improvements observed in the dynamic stretching group, especially in the 30–50 m distances, are consistent with previous studies reporting enhanced explosive power and stride efficiency following dynamic warm-up routines (Fletcher & Jones, 2004; Yamaguchi & Ishii, 2005). However, despite the lack of examination on any physiologically or biomechanically related variables in this experiment, it is highly possible that the better results following dynamic stretching may have been facilitated by factors such as movement preparation, increased muscle temperature, improved coordination, and other neuromuscular-related factors. All of which can be considered mere possibilities as the inclusion of electromyographic testing and biomechanics was not included in the experiment. Static stretching also produced performance gains; however, the smaller effect sizes support literature noting possible short-term reductions in muscle stiffness and force output following prolonged static stretching (Kay & Blazevich, 2012). Firstly, it should be emphasized that these findings should not be taken to mean that dynamic stretching is better for everyone in every athletic situation. Instead, these findings can help confirm the potential usefulness of dynamic stretching for short-term warm-ups before football games under certain circumstances described in this study. The correlation results indicated that anthropometric characteristics such as height, weight, and BMI were not strongly associated with sprint times in either group, suggesting that flexibility and neuromuscular preparedness may play a more prominent role in influencing sprint performance in this context. Nevertheless, these observations should be interpreted with some caution due to the design constraints of the study.

A number of limitations have to be pointed out when considering the results of the present study. First of all, it can be assumed that a smaller sample size negatively affected the statistical significance of the estimates. Furthermore, the length of the experiment (6 weeks) is rather short in terms of studying the long-term adaptation processes to physical training. Several potentially influential variables were not controlled, such as sleep quality, nutrition, fatigue, psychological readiness to participate in the program, and others that were known to influence sprint performance outcomes. In addition, the experiment included only male college football players that seriously limits its application for females, professional athletes, younger individuals, or athletes involved in other types of sports activities. Also, there were no direct physiological, biomechanical, or neuromuscular measurements which could shed light on the exact nature of the results obtained (Sanjaykumar et al., 2024; Panascì et al., 2025). Future studies would benefit from more rigorous designs, including larger and more diverse samples, randomized controlled trials, and the inclusion of psychological, nutritional, biomechanical, and hormonal variables to provide a more comprehensive understanding. Investigating differences across genders, training levels, and sport-specific demands may also enhance the practical applicability of the findings (Yevhen Mykhaliuk et al., 2024; Sanjaykumar et al., 2023; Kozina et al., 2024; Ikhsan et al., 2023).

## CONCLUSIONS

This study provides preliminary evidence that both static and dynamic stretching may enhance sprint performance in male college football players, with dynamic stretching showing comparatively greater improvements, especially over longer sprint distances. Nonetheless, considering factors like the small number of participants, short intervention period, lack of measurement of mechanism, and narrow population range, these results must be viewed in an exploratory perspective and cannot be taken as conclusive. While dynamic stretching could be a useful aspect in football warming up sessions, many more studies are needed before any concrete practical applications can be made.

## AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Ashokan Praveen: conceptualization, methodology, investigation, resources, writing-review & editing, supervision, writing-original draft and final approval the manuscript. Chandrababu Suresh: methodology, formal analysis, data curation and collection, supervision and final approval the manuscript. Sergio Sebastia-Amat: methodology, formal analysis, writing-review & editing and final approval the manuscript. Mert Kurnaz: methodology, formal analysis, writing-review & editing and final approval the manuscript. Grygus Igor: writing-review & editing, formal analysis, and final approval the manuscript. Yuliya Kalmykova: writing-review & editing, formal analysis, and final approval the manuscript. Swamynathan Sanjaykumar: conceptualization, methodology, investigation, writing-review & editing, writing-original draft and final approval the manuscript.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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## CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

## AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) ChatGPT was utilized to support language editing and enhance clarity during the preparation of this manuscript. All content was carefully reviewed, revised, and approved by the authors, who accept full responsibility for the accuracy and integrity of the work. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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