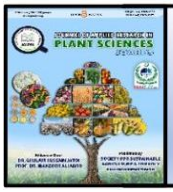
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Pruning Severity Impact on Morpho-biochemical and Yield Characters of Pomegranate Cultivar Pearl Under Semi-Arid Conditions of Central Punjab, Pakistan

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ABSTACT

Pruning is a crucial horticultural technique that considerably affects plant growth, quality and yield of pomegranate (*Punica granatum L.*). This study was conducted to evaluate the effect of four different pruning intensities comprising control (zero pruning) C_0, water shoot removal (WSR), sucker removal (SR), dead wood removal (DWR) and WSR+SR+DWR with four replications on fruit quality attributes including fruit weight, fruit size, color of arils, total soluble solids, titratable acidity, juice content and overall sensory acceptability. Experiment was carried out at Horticultural Research Institute, Faisalabad, Pakistan and laid out according to Randomized Complete Block Design comprised of four replications. Physical (Fruit size, fruit weight, No. of arils, juice percentage) and biochemical (total soluble solids, titratable acidity, vitamin C contents etc.) Treatment comprising suckers, dead wood and water shoots removal enhanced fruit size and increased total soluble solids levels leading to superior sweetness and marketability, excessive pruning, however, reduced fruit yield and promoted excessive vegetative growth. Disease incidence was maximum (19%) in control treatment (zero pruning) whereas, it recorded minimum (11.6%) in plants subjected to severe pruning (T_4). Fruit set percentage was recorded maximum (30%) in plants that undergone severe pruning (Sucker, dead wood and water shoot removal). Fruits harvested from plants subjected to severe pruning exhibited maximum fruit weight (185.3g) and fruit size (6585.3mm). Juice percentage is improved with increased level of pruning and recorded maximum (69.00%) in T_4 (WSR+SR+DWR) followed by T_2 (water shoot removal) that is statistically at par with T_4. Besides improving physical and biochemical characteristics severe pruning reduced per plant yield, observed minimum (16.50kg) in T_4. These results suggest that adopting an optimum pruning intensity can balance vegetative and reproductive growth, thus enhancing quality and commercial value of pomegranate fruit. These results provide practical insights for growers aiming to enhance fruit quality through precision orchard management.

KEYWORDS: Pruning intensity, Canopy architecture, Postharvest physiological attributes, Fruit set, yield performance, *Punica granatum*

INTRODUCTION

Pomegranate (*Punica granatum* L.) is a cherished, one of the oldest fruits in tropical, subtropical and mediterranean regions. It's a popular fruit due to exceptional organoleptic characteristics of arils as well as its therapeutic and nutritional benefits which are expedient in cancer treatment, indigestion and various other chronic ailments (Sharma and Singh 2018). The pomegranate fruit is being commercially cultivated in the Mediterranean region and other countries such as Iraq, Afghanistan, China, Iran, Spain, India, Pakistan, USA, Russia, Japan and Egypt (Nagaar *et al*., 2018).

Pruning plays a vital role in regulating canopy architecture, improving light distribution and enhancing air circulation within fruit trees both in conventional as well as under intensive planting systems (Woldegebriel, 2026). Mostly fruit plants are trimmed to increase shoots structure and plant canopy that makes branches less likely to breakdown under dense crop load, eradicates water shoots to develop fruit quality and reduces crop load, which allows different fruits to develop upto their full potential dimensions (Nagar *et al*. 2018). In 'Kinnow' mandarin, moderate pruning significantly improved fruit yield and quality attributes by maintaining a balance between vegetative growth and reproductive development (Umara *et al*., 2019).

The effects of pruning on pomegranate fruit quality have gained significant attention in recent years due to the increasing demand for high-quality fruits in the global market. Proper pruning practices can potentially enhance fruit size, color and chemical composition, ultimately affecting the overall fruit quality and marketability (Kahramanoglu and Usanmaz, 2016: (Umara *et al*., 2019).

Different pruning intensities have been shown to significantly affect growth and fruit quality in

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pomegranate, with optimized pruning improving yield and marketable traits (Noreen *et al.,* 2025). The study highlighted that appropriate pruning intensity improves canopy management, enhances light penetration, and ultimately contributes to better fruit size and overall quality (Noreen *et al*., 2025).

Various studies have been carried out to investigate the influence of pruning severity on sustainable fruit productions, disease incidence, sunburn, fruit splitting, growing habit, quality, marketable yield in fruit crops (Woldegebriel, 2026; Sharma and Singh 2018). A study shown that pruning practices significantly reduced incidence of various diseases on leaf and fruit surface (Umara *et al*. 2019). Former researches suggests that plants exhibits sympodia growth patterns without regular pruning practice, subsequently plants or trees growing in a profuse bush form (Sharma and Singh, 2018). A good plant canopy management of a tree results in high quality fruit along with three to four times higher fruit yields in numerous Citrus species owing to enhancement in number of newly emerging shoots resulting in new fruiting woods (Umara *et al.*, 2019).

Color development; a crucial aspect of fruit quality is also influenced by pruning. Improved light penetration within the tree canopy achieved through strategic pruning can lead to better fruit coloration. This improved color development is predominantly imperative for those varieties where exterior look of the commodity plays a substantial role in marketability. (Marini and Sherif 2025).

A number of factors such as cultivar characteristics, climatic conditions, plant age and production goals must be taken into account to optimize pruning levels for improved pomegranate fruit quality.

Unattended pomegranate (*Punica granatum* L.) plants with overcrowded canopies that block sunlight, lowers the photosynthesis, yield, and aril quality.

Because both under-pruning and over pruning disrupt the balance between vegetative and reproductive growth, local growers lacks standardized pruning protocols.

To address this gap, the current study evaluates different pruning levels to find the best for orchard management. The ultimate goal of pruning is to maximize canopy light penetration, total yield, fruit weight, and soluble sugar accumulation.

MATERIALS AND METHODS:

Experimental site: During the dormant season (winter) in 2024 & 2025 pomegranate plants of uniform size and age were selected/ tagged for pruning at experimental orchard Horticultural Research Institute, Faisalabad, Pakistan (Latitude. 31.42°N, Longitude 73.09°E, Elevation 189m). The experimental site has a semi-arid climate having extremely hot and humid summers and dry, mild winters. Soil of the research site is loamy with pH 8.5. There were total five treatments comprising control (zero pruning) C_0, sucker removal (SR), water shoot removal (WSR), dead wood removal (DWR) and WSR+SR+DWR with four replications. The twenty plants aged ten years with uniform growth and canopy were selected at random for pruning treatments during the experimentation. The pruning was carried out during winter season at dormant plant growth stage in the month of January. However, during the peak growing season in summer, pruning was also done to remove suckers arising from ground near main stems. A thick layer of bordeaux paste was applied after every pruning at all stubs to avoid any fungal attack (Figure.1 a,b,c,d). Other agronomic management practices were carried out uniformly to all plants under study throughout the whole research period.

Disease Incidence percentage (%): Incidence of disease was calculated by using the formula given as under:

Disease incidence on fruits (%) = No. of samples having diseased symptoms/ No. of total samples× 100.

Approximation of Physical Characters of fruits: The pomegranate fruits were harvested and collected in the second week of August at full ripened stage and the per plant yield (kgs) from each single selected plant was recorded using ordinal weighing balance (Sanyo). An electronic weighing scale was used to measure the weight of each fruit, total aril weight 100 aril weight (OHASU Corporation). Whereas the fruit diameter and length (mm) were recorded with the help of a digital caliper (Mitutoyo, 93888, Seiko, Japan). Total aril juice was prepared using a food processor (Panasonic, Malaysia). Juice percentage of arils was calculated by using the following formula:

Juice percentage (%) = Weight of Juice (g) / Weight of total arils (g) x 100

Approximation of Biochemical characters of fruits: After harvesting in the second week of August, fruit samples were transported to the pomology laboratory and the total soluble contents (TSS) of pomegranate juice were determined by a digital refractometer (PAL-1, ATAGO, Japan) and indicated in °Brix. Simultaneously, titratable acidity (citric acid contents) was recorded by an automatic tittrator (Hanna, 8443, Romania).

Estimation of Vitamin C: The vitamin C (mg/100mL) contents were determined by using titration-based method (Hussain et al. 2016). 2,6-

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dichlorophenolindophenol solution was standardized through titration against a known quantity of standard ascorbic acid mixed up with 4 percent oxalic acid till a tenacious dim pink color appeared, the volume of dye used was recorded (V_1). Then, the sample weight was taken, ground with 4% oxalic acid and filtered to obtain a pure extract to a fixed volume. Measured quantity of this sample extract was acidified and titrated with the standardized DCPIP dye until the same fade pink endpoint, that volume was recorded (V_2). Lastly, the ascorbic acid per 100 Ml was calculated by using ratio of the sample titration volume to standard dye vol. combined with the sample weight and dilution factors.



Figure 1. Pruning and fruit development stages of pomegranate: (a) Pruning of pomegranate plants during the dormant period; (b) Application of Bordeaux mixture to pruning cuts immediately after pruning; (c) Severely pruned pomegranate plant; and (d) Fruit development stage.

Statistical Analysis: Experimental data was then subjected to Analysis of Variance (ANOVA) (Steel et al. 1997) by using a computer software (Statistix 8.1 version) (Tallhassee Florida, USA) comprised of four replicates. Means were compared using Tuckey's honest significance difference (HSD) test at 5 percent probability level ($\alpha = 5\%$).

RESULTS

Disease incidence percentage (%): The analyzed data revealed that pruning treatments significantly influenced disease incidence. The highest disease incidence (19.6%) was recorded in the control treatment (T_0: No Pruning), which was statistically different from all pruning treatments. Among all the tested pruning practices, suckers removal (T_1) decreased disease incidence up to 17.8%, followed by that of water shoots removal (T_2) with 16.5% and dead wood removal (T_3) with 14.2%. Every treatment varied significantly from each other at the 5 percent probability level (α=5%; HSD=0.94), which showed a notable decrease in disease incidence (%) with increased pruning intensity. Plants subjected to treatment T_4 (removal of all three: suckers, water shoots and dead wood) exhibited minimum disease incidence (11.6%), that was significantly lesser than all other pruning intensities.

Fruit set percentage (%): Various pruning treatments significantly affected fruit set percentage in this study ($P \leq 0.05$). The plants subjected to treatment T_4 (suckers, water shoots and dead wood removal) exhibited maximum fruit set (30.5%), that was statistically greater to the all other treatments. Among the other pruning

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treatments, T_0 (21.9%) showed significantly higher fruit set compared to T_2 (19.0%), while T_3 (20.5%). Minimum fruit set percentage was observed in plants subjected to sucker removal (T_1).

Fruit size: The data presented in table 1 revealed that fruit diameter significantly impacted by different pruning treatments at the 95% confidence level ($P \leq 0.05$). The highest fruit diameter (6585.3 mm^2) was found in under treatment T_4.

Fruit physical attributes:

Fruit weight: Fruit weight was significantly affected by various pruning intensities ($P \leq 0.05$). The maximum fruit weight was noted in T_4 (185.3 g) followed by T2 (183.0), significantly higher among the treatments. The fruits harvested from plants subjected to T_3 and T_1 exhibited weight of 177.9 and 177.8 respectively that is statistically at par to each other. Moreover, lowest fruit weight (161.0) was recorded in treatment T_0.

Table 1. Effect of pruning severity on morphological characteristics of Pomegranate (*Punica granatum* L.) at 5 percent probability level (α = 5%)

	Disease incidence	Fruit Set Percentage	Fruit Diameter	Fruit Length	Fruit Size	Fruit weight
T_0	19.6 a	21.93b	72.4c	76.46 c	5405.7 c	161.0 d
T_1	17.8 b	18.13 c	70.7 d	76.46 c	5762.7 b	177.8 cd
T_2	16.5c	19.0 bc	75.8b	79.56 b	5735.3 b	183.0 b
T_3	14.2d	20.5 bc	72.5c	76.06 c	5514.3 c	177.9c
T_4	11.6 e	30.5 a	78.4 a	83.96 a	6585.3 a	185.3 a
SE (±)	0.27	1.07	0.31	0.43	40.69	0.92
HSD Value	0.94	3.71	1.09	1.49	140.33	3.17

Where, The dissimilar letters shows significantly dissimilar at $P \leq 0.05$, whereas, T_0= Control; T_1= Removal of suckers; T_2= Removal of water shoots, T_3= Removal of dead wood;T_4= Suckers+ water shoots +dead wood removal; SE= Standard error & HSD= Tukey's Honest Significant Difference

Table 2. Effect of pruning severity on morphological characteristics of Pomegranate (*Punica granatum* L.) at 5 percent probability level (α = 5%)

	Rind Thickness	Aril Count	Hundred Aril Weight	Juice percentage	Yield per plant
T_0	2.80 a	406.00 e	24.67 c	66.70 c	30.86 a
T_1	2.73 a	616.67 c	26.20 bc	68.13 b	28.20 ab
T_2	1.90 b	771.00 a	26.56 b	69.00 ab	27.90 ab
T_3	2.90 a	588.33 d	25.50 bc	65.50 c	22.67 bc
T_4	2.0 b	645.00 b	29.83a	69.00 ab	16.50 c
SE (±)	0.14	5.49	0.49	0.34	2.03
HSD Value	0.49	18.96	1.70	1.20	7.02

Where, The dissimilar letters shows significantly dissimilar at $P \leq 0.05$, whereas, T_0= control; T_1= Removal of suckers; T_2= Removal of water shoots, T_3= Removal of dead wood;T_4= Suckers+ water shoots +dead wood removal; SE= Standard error & HSD= Tukey's Honest Significant Difference

*Table 3: Effect of pruning severity on biochemical characteristics of Pomegranate (*Punica granatum* L.) at 5 percent probability level (α = 5%)

	TSS	TA	Vit. C contents
T_0	14.56 bc	0.86 a	11.33 cd
T_1	14.23 c	0.76 ab	11.63 c
T_2	15.16 ab	0.74 ab	12.06 b
T_3	15.96 a	0.78 ab	11.0 d
T_4	15.13 ab	0.62 b	13.23 a
SE (±)	0.170	0.060	0.1229
HSD Value	0.589	0.207	0.4239

Where, The dissimilar letters shows significantly dissimilar at $P \leq 0.05$, whereas, T_0= Control; T_1= Removal of suckers; T_2= Removal of water shoots, T_3= Removal of dead wood ;T_4= Suckers+ water shoots +dead wood removal; SE= Standard error & HSD= Tukey's Honest Significant Difference

Rind thickness: Statistically significant results were obtained regarding rind thickness in this study at $P \leq 0.05$. The highest rind thickness (3.20 mm) was recorded under treatment T_2, followed by T_3 (2.90 mm) and control treatment (2.80 mm). Fruits harvested from the plants exposed to treatment T_1 exhibited a rind thickness of 2.73 mm, however, rind thickness was observed lowest in plants under pruning level T_4 (2.0

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mm). The HSD test confirmed that the pruning intensity had a significant impact on rind development.

Aril count: Aril count was significantly influenced by different pruning treatments at 5% probability level. The highest number of arils per fruit (771.0) was recorded under treatment T_2, followed by T_4 (645.0) and T_1 (616.6). Treatment T_3 produced 588.3 arils per fruit, while the lowest aril count (406.0) was observed under T_0. The observed differences among treatments exceeded the HSD value (18.9), confirming that pruning practices significantly affected aril development.

hundred aril weight (g): As the data demonstrated in table. 2 weight of hundred arils was significantly affected by various pruning levels ($P \leq 0.05$). The maximum hundred aril weight (29.8 g) was observed in fruits of plants subjected to treatment T_4, that showed a notable improvement in aril mass when compared to fruits of other treatments. However, minimum hundred aril weight (24.67 g) was exhibited by plants of control treatment. Weight of 100 arils was recorded 26.56 g in T_2 treatment that is statistically at par to that of T_1 which gave 26.20 g weight of hundred arils. The variation among treatment means exceeded the HSD value (1.7), which proved the significant impact of pruning on weight of arils of pomegranate fruit.

Juice percentage (%): The data presented in table 2 revealed that pruning treatments had significant impact on juice percentage of the pomegranate fruits at $P \leq 0.05$. However, highest juice contents (69%) were exhibited by the fruits of plants subjected to treatments T_2 and T_4, representing improved juiciness of arils as compared to other treatments, followed by T_1 (68.1%), whereas plants exposed to pruning under $T_3$and T_0 exhibited relatively less juice percentage (65.5% and 66.7%) respectively. The HSD value showed that the treatment means had significant differences which confirmed the effect of pruning on juice contents of pomegranate fruit.

Yield (kg/plant): The analyzed data showed that yield per plant was significantly impacted by different pruning intensities at $P \leq 0.05$). The highest per plant yield (30.86) was recorded in the plants subjected to treatment T_0, followed by T_1 (28.20) and T_2 (27.90) as depicted in the table 2. Treatment T_3 produced a lower yield of 22.67 kg/plant, while the minimum yield (16.50) was observed under T_4. Moreover, the fruits of treatment T4 were of good quality compared to that of T_0. The mean differences among treatments were greater than the HSD value (7.02), so, it confirms that pruning practice had a substantial impact on overall yield of the plant.

DISCUSSION

Various pruning techniques can considerably influence fruit quality in Pomegranate. Appropriate pruning improves sunlight penetration within the plant canopy and air circulation which are crucial for good fruit development. The improved sunlight exposure can lead towards better pigment development of the arils, greater antioxidant contents and increased accumulation of sugars (Di Stefano *et al.* 2020). Pruning also helps in managing tree size and shape, potentially resulting in larger, more uniform fruits (Nagar *et al*. 2018). Results obtained regarding disease incidence reduction are in line with Mustafa *et al.,* (2023); Singh *et al.,* (2012). The findings of our current search regarding the reduced disease incidence by various pruning levels are matched with results of Lemus (2010) Riedle-Bauer *et al.,* (2010); Sharma and Singh (2018). The decreased disease incidence may be due to high daylight penetration in fruit surface, proper ventilation results in low humidity level which helps to control occurrence of bacterial blight (Sharma et al., 2017). Improved ventilation through the plant canopy of pomegranate lead to reduced disease ocuurence (Mustafa *et al.,* 2023).

The substantial increase in aril count under T_2 may be attributed to improved canopy structure and enhanced photosynthetic efficiency resulting from effective pruning. Better light penetration and reduced intra-canopy competition likely enhanced carbohydrate accumulation and assimilate translocation toward developing ovules, thereby promoting higher seed and aril formation. However, the minimum number of arils in the fruits obtained from plants of T_0 may be linked with poor canopy ventilation and limited assimilate accumulation, restricted reproductive development. These results suggest that optimum pruning severity is imperative for increasing pomegranate fruit fresh weight, yield and productivity. On the other hand, the lower aril weight seen under T0 might be due to increased intra-canopy competition and decreased photosynthetic efficiency, which would limit the amount of assimilate available to the arils. The findings of current investigation are in line with the results of Mustafa *et al.,* (2023). Pruning generally improves fruit quality by enhancing the exposure of leaves and fruits to sunlight, which is essential for photosynthesis and the accumulation of sugars and pigments such as anthocyanins. These pigments contribute to the distinctive red color of pomegranate arils, a critical sensory quality attribute, as suggested by the study on climate effects on anthocyanin accumulation (Borochov-Neori *et al.,* 2011). Moreover, adequate sunlight and airflow facilitated by pruning can reduce the incidence of diseases and improve the fruit's overall biochemical profile, including antioxidant activity and nutrient content (Noreen *et al.,* 2025).

The pruning treatments substantially impacted total soluble solid contents and titratatble acidity during current research, comparable to the results portrayed by Sharma *et al*. (2017). The maximum total soluble solid

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contents were obtained from T_3, as described earlier by (Sharma and Singh 2018). Greater total soluble solids in fruit juice could be credited to greater carb accumulation and adequate reserve to fruits due enhanced sunlight exposure and photosynthetic rate consequent in extra TSS and sugar accumulation in the fruit collected from pruned plants (Thakur *et al*., 2026; Yadav *et al.,* 2023; Ashraf and Ashraf 2014 & Sharma and Singh 2018). Another interesting reason for the increased TSS may be the increased leaf/fruit ratio of trimmed plants compared to un pruned ones, contributing to greater TSS concentration due to improved secondary metabolites production (Adhikari and Kandel, 2015).

Pruning maintains plant health and vigor by reducing various abiotic stressors which balances the vegetative as well as reproductive performance of fruiting plants. However, various pruning intensities also affect physiological, physical, biochemical properties of fruits (Intrigliolo and Roccuzzo 2011). Pruning aids to increase sunlight exposure to the plant, standardize air flow and decrease humidity around the microclimate of pomegranate plat canopy. The findings observed during the current experimentation regarding the reduction in disease incidence by pruning management are in line with the results revealed by Riedle-Bauer *et al.* (2010); Lemus (2010) and Sharma and Singh (2018). The fruits obtained from plants undergo T_3 exhibited higher juice percentage, whereas rind thickness was reduced. So, it is proposed that the upsurge in juice contents of fruits from pruned plants may be owing to improved daylight infiltration, improved photosynthesis process and eventually greater photosynthates accumulation, as reported previously by (Nasir *et al.,*2016; Sharma and Singh, 2018). The pruning intensities considerably affected total soluble solids and titratable acidity during the current investigation, similar to results described by Sharma *et al.* (2018). The maximum values for total soluble solids were found from treatment T_3, as reported previously by (Sharma and Singh, 2018). Greater total soluble solids in fruit juice could be attributed to maximum carbohydrate accumulation and enough supply due to an increase in sunlight infiltration and ultimately photosynthetic rate, subsequently more sugar accumulation, TSS and high maturity index in fruits harvested from pruned plants (Hasani and Rezaei 2007; Ashraf and Ashraf 2014 and Sharma and Singh 2018). An additional factor contributing to the elevated TSS could be the increased leaf-to-fruit ratio in pruned trees compared to the control group, which enhances metabolite production and results in higher TSS levels (Adhikari and Kandel 2015). Various pruning levels had a significant impact on antioxidant activity in this study, aligning with the outcomes of Sharma and Singh (2018). Phenolics, which are secondary metabolites in plants, play a crucial role in plant defense during stress and tend to rise under such conditions (Lavolla *et al*. 2000; Assrey *et al.* 2013). At time of harvest, relatively higher phenolic contents were recorded in fruits produced by pruned plants compared to those obtained from un pruned plants (Umara *et al.* 2019).

The enhanced fruit weight was observed under T_4 treatments may be due to better canopy volume management and good source to sink relationship resulted from optimum pruning severity. Reduced competition among fruits and better light infiltration likely to improve photosynthesis and carbohydrate buildup, thus, enhanced the translocation of assimilates towards fruits. This stimulates cell division and enlargement eventually increased final weight of fruit at harvest time. Conversely, minimum fruit weight under treatment (T_1) plants may be linked with decrease sunlight penetration and highest competition within plant canopy that limits assimilate availability for development. These results suggests that proper pruning intensity plays crucial role in improving the number of palatable and marketable pomegranate fruits by increasing juice contents, total soluble solids, fruit size and overall fruit quality. The observation noted during the current study are in line with the outcomes of Noreen *et al.* (2025).

Weight of fruit, size of fruit, weight of hundred arils and juice percentage increase with pruning severity during the current examination, fruit size depends on the accessibility and carbohydrate supply from the tree canopy and our outcomes are in line with the findings reported by Sharma and Singh (2018), Mustafa *et al.,* (2023) and Adhikari and Kandel 2015).

CONCLUSION

The results recorded during our study showed the significant impact of various pruning intensities on pomegranate fruit quality attributes by reducing incidence of disease spread. Among all the treatments applied to pomegranate plants, quality attributes (TSS etc.) were improved and recorded best in T_4 (removal of suckers, dead wood & water shoots), however, a substantial decrease in per plant yield was recorded in the same treatment. A farmer may go for severe pruning (T_4) to get premium quality produce compromising overall per plant yield.

CONFLICT OF INTEREST

All the authors have no conflict of interest.

AUTHOR CONTRIBUTIONS

H.F. conceived and designed the research; H.F., M.A., M.A., S.R., N.S., S.A., and M.N. conducted the experiments, collected and analyzed the data, and contributed to manuscript preparation. H.F. supervised

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the research and revised the manuscript. All authors read and approved the final manuscript.

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