ORIGINAL ARTICLE

Factors related to shooting performance in 8–12-year-old basketball players

Osman Karaca . *Department of Physiotherapy and Rehabilitation. Faculty of Health Sciences. KTO Karatay University. Konya, Türkiye.*
Latife Nur Girgiç. *Pera Basketball Sports Club. Konya, Türkiye.*
Sevgi Betül Çuhadar. *Independent Researcher. Konya, Türkiye.*

ABSTRACT

This study aimed to investigate the relationship between shooting performances, specifically free throw (FT) and turn-around jump shot (TJS), and individual characteristics, physical performance, and proprioception in child basketball players. FT and TJS were evaluated with 10-shot trials. Individual data were collected via questionnaire. Lower limb explosive power was measured by the Sargent jump test (SJT), core endurance by the plank test, and shoulder, elbow, wrist proprioception by joint repositions error (JRE) tests. This cross-sectional study was conducted with 38 basketball players (age: 9.9 ± 1.5 years). FT and TJS correlated positively with SJT (ρ = .402, .388) and plank (ρ = .349, .342), respectively (p < .05). A significant positive correlation was found between FT and body height (ρ = .463), TJS and basketball experience (ρ = .352) (p < .05). Also, a negative correlation was found between plank and JRE-shoulder (ρ = - .431, p < .05). Shooting performance (FT and TJS) related to physical performance (lower limb explosive power and core muscles endurance). Improved FT performance was associated with increased body height, while TJS performance was related to longer experience. Understanding shared and distinct correlates of shooting skills can guide targeted assessment and training strategies.

Keywords: Performance analysis, Paediatrics, Free throw, Turn-around jump shot, Explosive strength, Core muscle endurance, Proprioception.

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Corresponding author. *Department of Physiotherapy and Rehabilitation, KTO Karatay University, Faculty of Health Sciences. Konya, Türkiye.*
E-mail: osman.karaca@karatay.edu.tr
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INTRODUCTION

Participation in sports has been reported to support children's personal, social, and physical development, such as health, socialization, teamwork, self-esteem, stress management, and reduced screen time, with these benefits being enhanced by supportive coaching environments and parents who reinforce teachable moments at home (Neely & Holt, 2014; Peyer & Smith, 2022). Basketball, one of the most popular team sports among children, is a game in which the winner is determined by the total number of points scored. One of the primary methods of scoring involves various shooting techniques, such as free throws, jump shots, and turn-around jump shots. Shooting skills are a key determinant of scoring success in basketball.

The performance of various basketball shot types is related to individual factors including body height and basketball playing experience, along with physical performance indicators such as explosive muscle strength (Okazaki et al., 2015; Okazaki & Rodacki, 2018). When examining the physical performance of basketball players, elite athletes have been found to possess greater lower extremity muscle strength, achieve higher vertical jump heights, and demonstrate superior agility compared to their peers (Han et al., 2023). In the literature, while some studies report no significant relationship between free throw performance and lower extremity muscle strength, there is evidence indicating that lower extremity muscle strength, particularly in relation to shooting distance, can influence ball release velocity in the upper extremity during jump shots (Cabarkapa et al., 2022; Nakano et al., 2020). Unlike the standard jump shot, the turn-around jump shot involves the player starting with their back to the basket, then quickly turning to face the basket before jumping to execute the shot. After turning to face the basket, the player must quickly prepare their body to execute the shot. This study will examine the relationship between lower extremity explosive muscle strength and free throw shooting. This will both contribute to the literature's diverse findings and contribute new insights to the literature by examining the relationship between lower extremity explosive muscle strength and turn-around jump shots.

In basketball players, another frequently studied muscle group, distinct from lower extremity muscles, is the core musculature. Strong and enduring core muscles are important for maintaining lower extremity muscle function and sustaining athletic performance (Tazji et al., 2023). Furthermore, a significant relationship has been identified between core muscle endurance and postural stability in basketball players, which may positively influence their overall athletic performance (Cengizhan et al., 2019).

In competitive sports such as basketball, precise and coordinated body movements are critically important for success. Proprioception can be defined as the ability to determine the position and movement of body segments in space by integrating sensory signals received from mechanoreceptors (Han et al., 2016). Moreover, proprioceptive signals enable us to perceive the force and effort generated by our muscles, as well as the weight of the objects we lift (Héroux et al., 2022). In the literature, various studies have reported no significant relationship between elbow and wrist proprioception and free throw performance or standing free throw scores, while shoulder proprioception has been found to have a borderline significant association with free throw performance (Kaya et al., 2012; Sevrez & Bourdin, 2015).

Shooting is arguably the most decisive skill for scoring in basketball and, ultimately, for winning games. While free throw performance has been widely studied, research on the turn-around jump shot, a technically demanding and game-relevant skill, remains surprisingly scarce. To our knowledge, this is the first study to simultaneously and comparatively examine the factors associated with both free throw and turn-around jump shot performance. By addressing this gap, we aim to offer novel and meaningful insights that could inform both player development and training strategies in basketball. The aim of this study is to investigate the

relationships between different shooting techniques (free throw and turn-around jump shot) performance and individual characteristics (height, BMI, basketball experience, age), physical performance (lower extremity explosive muscle strength, core muscle endurance), and proprioception (shoulder, elbow, and wrist) in child basketball players.

MATERIAL AND METHODS

Study design

A cross-sectional study was conducted to investigate the relationships between free throw and turn-around jump shot performance and individual characteristics, physical performance, and proprioception in basketball players aged 8–12 years.

Participants

This study was conducted between May 15 and June 15, 2025, at the Pera Basketball Sports Club. Participants aged 8–12 years had been playing basketball regularly for at least one year and had current membership in a basketball club, regardless of duration. Individuals who had undergone any surgical procedures within the last six months or had any health conditions that could affect the assessments (particularly musculoskeletal disorders) were excluded from the study.

Prior to the study, ethical approval was obtained from the KTO Karatay University Ethics Committee (Date: May 8, 2025; Decision No: 2025/007). Before participation, both the participants and their parents were informed about the study, and written informed consent was obtained.

Sample size estimation

A priori power analysis was conducted using G*Power (version 3.1.9.7) to determine the minimum required sample size for detecting a significant correlation using a two-tailed test. The effect size ($\rho = .50$) was derived from a previous study that reported a moderate negative correlation between free-throw performance and elbow joint position sense (Sevrez & Bourdin, 2015). Power analysis ($\alpha = .05$, $1–\beta = .80$) indicated that at least 29 participants were needed to detect a significant correlation.

Procedures

In the study, participants' individual characteristics, shooting performance, lower extremity explosive muscle strength, jump height, proprioception, and core muscle strength were assessed.

Individual and descriptive characteristics

Individual and descriptive information such as age, gender, height, weight, body mass index, and duration of basketball experience (in sports club) of the individuals in the study sample were recorded using a demographic information form.

Assessment of shooting performance

Participants' performance in free throws and turn-around jump shots was assessed. In the turn-around jump shot, the player started with their back facing the basket, then turned to face the basket and performed the shot while jumping. Free throws were performed at 4.6 m and turn-around jump shots at 3 m from the basket. For each type of shot, participants first performed 3 practice trials, followed by 10 recorded attempts. Each successful shot was scored as 1 point, and unsuccessful shots were scored as 0 points.

Assessment of lower extremity explosive muscle strength

Explosive lower extremity muscle strength was assessed using the Sargent jump test. In the initial measurement, the participant stands upright with feet fully contacting the ground. The dominant arm is extended overhead parallel to the wall, and the highest reachable point is marked. In the second measurement, the participant is instructed to jump vertically as high as possible and mark the wall with the dominant hand at the peak of the jump (do Amaral Vasconcellos et al., 2012; Dos Reis et al., 2024). The distance between the two marks is recorded as the jump height. The test is repeated three times, and the highest score is recorded. An increase in jump height indicates an improvement in explosive muscle strength.

Assessment of core muscle endurance

The plank test was used to assess core muscle endurance. In this test, participants are asked to place their hands and elbows on the mat, with elbows positioned directly under the shoulders, and raise themselves onto their toes. The objective is to maintain the plank position, keeping the spine and pelvis in a neutral alignment, for as long as possible. Prior to the test, participants were verbally informed, shown a demonstration, and guided through the correct position and relevant procedures when necessary. A stopwatch was started on the command "Start!" and stopped when the participant was unable to maintain a straight back position (deviation > 5 cm measured with a ruler), lowered onto the mat, or successfully completed the isometric hold for 3 minutes. The duration was recorded to the nearest second (Laurson et al., 2022).

Assessment of proprioception

Proprioception was assessed via joint reposition error (JRE) using a digital inclinometer. JRE measurements were performed on the dominant upper extremity. The joint to be assessed is first positioned at a predetermined angle, and the participant is asked to memorize this position. The joint is then returned to its starting position. With the participant's eyes closed, they are instructed to reposition the joint to the previously memorized angle (120° shoulder flexion, 100° elbow flexion, and 30° wrist extension). The absolute difference between the initial target angle and the angle achieved by the participant is recorded as the JRE. The test is repeated three times, and the best (minimum) value is recorded. A smaller JRE indicates better proprioceptive ability (Hillier et al., 2015; Jacobs et al., 2025).

Statistical analysis

The data in this study were analysed using IBM SPSS Statistics software. Categorical variables were presented as frequencies and percentages, while continuous numerical variables were reported as mean ± SD and median with interquartile range (IQR). The normality of continuous numerical data was assessed. For correlation analyses, Spearman's correlation test was used for variables that did not meet the assumptions of normal distribution. Correlation coefficients were interpreted as follows: values between .00 and ±.30 were considered negligible, ± .30 to ± .50 as weak, ± .50 to ± .70 as moderate, ± .70 to ± .90 as high, and ± .90 to ± 1.00 as very high correlations (Mukaka, 2012). The 95% confidence intervals for the Spearman correlation coefficients were estimated using the bootstrap method with 1000 resamples. The significance level of $p < .05$ was considered statistically significant.

RESULTS

The mean age of the participants was 10.03 ± 1.70 years, and the mean body mass index (BMI) was 20.04 ± 3.08. Other individual characteristics of the participants are presented in Table 1.

Table 1. Individual characteristics of participants.

	Mean ± SD	Median- IQR (25/75)	n (%)
Age (years)	9.92 ± 1.53	10.00- 8.75/12.00	-
BMI (kg/m²)	20.04 ± 3.08	19.97- 17.48/21.90	-
Height (cm)	143.79 ± 12.68	140.50- 133.50/154.50	-
Basketball experience[a] (years)	1.30 ± 1.38	0.67- 0.50/2.25	-
Gender			
Female	-		28 (73.7)
Male	-		10 (26.3)
Dominant hand			
Right	-		34 (89.5)
Left	-		4 (10.5)
Dominant foot			
Right	-		34 (89.5)
Left	-		4 (10.5)

Note. SD: Standard Deviation, IQR: Interquartile Range, REA, BMI: Body Mass Index, [a] As a Registered Member of a Sports Club.

The participants' free throw shooting performance averaged 2.55 ± 2.07, while the turn-around shot performance averaged 3.24 ± 1.88. Detailed numerical data on the participants' shooting performances, physical performance, and joint reposition error angles are presented in Table 2.

Table 2. Descriptive statistics of shooting performance, physical performance, and joint reposition errors.

	Mean ± SD	Median- IQR (25/75)
Free throw	2.55 ± 2.07	2.0- 1.00/4.00
Turn-around jump shot	3.24 ± 1.88	3.0- 2.00/4.00
Sargent jump (cm)	26.73 ± 8.72	24.00- 20.00/33.25
Plank (s)	67.73 ± 44.30	61.57- 33.13/97.52
JRE shoulder	10.35 ± 6.54	8.67- 4.83/14.00
JRE elbow	7.77 ± 4.75	7.00- 4.25/10.00
JRE wrist	6.54 ± 4.14	4.83- 2.92/9.83

Note. SD: Standard Deviation, IQR: Interquartile Range, JRE: Joint Reposition Error.

Correlation analyses were conducted to investigate the relationships between shooting performances and various participant characteristics. A weak positive correlation was found between participants' free throw and turn-around Jump Shot performances (ρ = .437, 95% CI [0.147, 0.681], p = .006). A weak positive correlation was observed between free throw performance and body height (ρ = .463, 95% CI [0.117, 0.712], p = .003). Turn-around jump shot performance showed a weak positive correlation with the duration of playing basketball as a registered member of a sports club (ρ = .352, 95% CI [0.049, 0.582], p = .030). No significant correlations were found between shooting performances and other descriptive statistics (p > .05) (Table 3).

Table 3. Correlations between shooting performance and descriptive statistics.

		ρ	95% CI	p-Value
Free throw	Age (years)	0.238	[-0.126, 0.542]	.15
Turn-around jump shot		0.194	[-0.133, 0.484]	.24
Free throw	BMI (kg/m²)	0.170	[-0.148, 0.467]	.31
Turnaround jump shot		-0.064	[-0.389, 0.260]	.70
Free throw	Height (cm)	0.463**	[0.117, 0.712]	.003
Turn-around jump shot		0.285	[-0.054, 0.545]	.08
Free throw	Basketball experience[a] (years)	0.216	[-0.113, 0.542]	.19
Turn-around jump shot		0.352*	[0.049, 0.582]	.03

*Note. [a] As a Registered Member of a Sports Club, ρ: Spearman's rho, CI: Confidence Interval, p** < .01, p* < .05.*

Correlation analyses were conducted to investigate the relationships between shooting performances, physical performance tests, and reposition error angle values. A weak positive correlation was found between free throw performance and the Sargent Jump Test (ρ = .402, 95% CI [0.087, 0.666], p = .01), as well as between Turn-around jump shot performance and the Sargent Jump Test (ρ = .388, 95% CI [0.107, 0.611] p = .02). Similarly, both free throw and turn-around jump shot performances showed weak positive correlations with the Plank test (ρ = .349, 95% CI [0.026, 0.622] and ρ = .342, 95% CI [0.016, 0.627] respectively; p < .05). However, no significant correlations were observed between shooting performances and reposition error angle values (p > .05). Detailed information on the correlation results is presented in Table 4.

Table 4. Correlations between shooting performance, physical performance tests, and joint reposition error values.

		ρ	95% CI	p-Value
Free throw	Sargent jump (cm)	0.402*	[0.087, 0.666]	.01
Turn-around jump shot		0.388*	[0.107, 0.611]	.02
Free throw	Plank	0.349*	[0.026, 0.622]	.03
Turn-around jump shot		0.342*	[0.016, 0.627]	.04
Free throw	JRE-shoulder	0.012	[-0.355, 0.364]	.94
Turn-around jump shot		-0.151	[-0.432, 0.185]	.37
Free throw	JRE-elbow	0.166	[-0.159, 0.446]	.32
Turn-around jump shot		-0.019	[-0.355, 0.341	.91
Free throw	JRE-wrist	-0.047	[-0.407, 0.307]	.78
Turn-around jump shot		-0.166	[-0.472, 0.152]	.32

*Note. JRE: Joint Reposition Error, ρ: Spearman's rho, CI: Confidence Interval, p** < .01, p* < .05.*

Another result found because of the correlation analysis is the weak and negative relationship between the joint reposition error measured in the shoulder joint and the plank time (ρ = -.431, 95% CI [-0.677, -0.131] p = .007). This result was not initially included in the main tables, as it falls outside the primary scope of the study. However, given its potential importance, we report the correlation coefficient, confidence interval, and p-value here, and further discuss its implications in the Discussion section. Detailed pairwise correlation results are available in the supplementary material (Table S1, and Table S2).

Table S1. Pairwise correlations results between shooting performance and individual characteristics.

		Free throw	Turn-around jump shot	Age (years)	BMI (kg/m²)	Height (cm)
Turnaround shot	ρ	0.437**				
	p-Value	.006				
Age (years)	ρ	0.234	0.201			
	p-Value	.16	.23			
BMI (kg/m²)	ρ	0.170	-0.064	0.154		
	p-Value	.31	.70	.36		
Height (cm)	ρ	0.463**	0.285	0.867**	0.267	
	p-Value	.003	.08	.001	.10	
Basketball experience * (years)	ρ	0.216	0.352*	0.731**	-0.076	0.731**
	p-Value	.19	.03	.001	.65	.001

*Note. * As a Registered Member of a Sports Club, BMI: Body Mass Index, ρ: Spearman's rho, p** < .01, p* < .05.*

Table S2. Pairwise correlations results between shooting performance, physical performance tests, and joint reposition error values.

		Free throw	Turn-around jump shot	Sargent jump (cm)	Plank	JRE-shoulder	JRE-elbow
Turnaround shot	*ρ*	0.437**					
	p-Value	.006					
Sargent jump (cm)	*ρ*	0.402*	0.388*				
	p-Value	.01	.02				
Plank	*ρ*	0.349*	0.342*	0.530**			
	p-Value	.03	.04	.001			
JRE-shoulder	*ρ*	0.012	-0.151	-0.172	-0.431**		
	p-Value	.94	.37	.30	.007		
JRE- elbow	*ρ*	0.166	-0.019	-0.195	-0.081	0.084	
	p-Value	.32	.91	.24	.63	.62	
JRE- wrist	*ρ*	-0.047	-0.166	-0.213	-0.107	-0.252	-0.212
	p-Value	.78	.32	.20	.52	.13	.20

Note. JRE: Joint Reposition Error, ρ: Spearman's rho, p** < .01, p* < .05.

DISCUSSION

This study aimed to investigate factors that may be associated with free throw and turn-around jump shot performance, including individual characteristics, lower extremity explosive muscle strength, core muscle strength, and proprioception. To our knowledge, this is the first study to simultaneously and comparatively examine the factors associated with both free throw and turn-around jump shot performance. When individual variables were considered, the results of this study revealed a weak yet significant correlation between improved free throw performance and increased body height. Additionally, there was a significant relationship between improvement in turn-around jump shot performance and longer duration of playing basketball as a registered member of a sports club. No significant relationship was found between shooting performances and age or BMI values. Regarding the relationships between shooting performances, physical performance, and proprioception, the findings showed a significant association between increased free throw and turn-around jump shot performance and greater lower extremity explosive strength. Similarly, there was a significant relationship between shooting performance (both free throw and turn-around jump shot) and increased endurance of core muscles. However, no significant relationship was found between shooting performances and proprioception of the shoulder, elbow, or wrist joints.

In this study, a weak but significant relationship was found between improved free throw performance and body height. However, no significant relationship was found between turn-around jump shot performance and height. In a previous study, height was found to be associated with sport-specific skills in basketball players (Mikołajec et al., 2025). Increased release height, which is associated with greater body height, is a factor that positively influences shooting performance. (Okazaki & Rodacki, 2018). The relationship found in our study between increased free throw performance and greater height is consistent with the literature. However, no significant relationship was observed between turn-around jump shot performance and body height. In the turn-around jump shot technique, since the player initially faces away from the basket, accurate perception and alignment of the target during the turn are critical. At this point, other individual differences, such as varying levels of experience, may have diminished the advantage typically associated with greater height. Another finding of this study was that an increase in turn-around jump shot performance was associated with longer basketball playing experience, whereas no such relationship was found between free throw performance and duration of playing basketball. In a study conducted with elite basketball players,

increasing experience over the years was found to be associated with higher free throw percentages and a greater number of assists. However, due to observed individual differences in other performance indicators, it was emphasized that individualized analytical approaches are needed to better understand player performance (Lorenzo et al., 2019). Given that the participants in this study had relatively short durations of professional basketball experience, the absence of a significant relationship between free throw performance and playing experience may be expected. Since the turn-around jump shot involves more components compared to a free throw, a significant relationship may have been detected despite the limited playing experience. We suggest that the association between experience and turn-around jump shot performance, but not with free throw performance, may be due to the more complex nature of the turn-around jump shot.

In this study, improvements in shooting technique performance were found to be associated with increases in lower extremity explosive muscle strength and core muscle performance. However, a previous study on this topic reported no significant relationship between lower extremity explosive strength and shooting performance (including free-throw, two-point, and three-point shooting) (Cabarkapa et al., 2022). It has been suggested that this result may be influenced by the participants' experience with basketball playing and resistance training, and that the participants may have already possessed sufficient lower extremity strength required for shooting. One study investigating the relationship between free throw performance and elbow and wrist proprioception in basketball players reported no significant correlation between free throw scores performed in a standing position and joint position sense (Gür et al., 2022; Nakano et al., 2020). It has also been noted that during shooting, different body segments work in synergy, and that imbalances in this intersegmental synergy may negatively affect shooting performance (Matsunaga & Oshikawa, 2022). A study on this subject demonstrated that fatigue in the lower back muscles can negatively affect jump performance and landing mechanics, thereby reducing shooting success in basketball players and altering lower extremity biomechanics (Lin et al., 2022).

Proprioception is another variable examined in this study that may be related to shooting performance. According to results of this study no significant relationship was found between shooting technique performance and proprioception values of the shoulder, elbow, and wrist. The literature presents varying findings on this topic. One study investigating the relationship between free throw performance and elbow and wrist proprioception in basketball players reported no significant correlation between free throw scores performing standing and joint position sense. However, significant correlations were found between free throw scores performed while seated and joint position sense (Sevrez & Bourdin, 2015). In another study conducted with professional basketball players, a borderline significant relationship was found between shoulder proprioception and free throw performance (Kaya et al., 2012). A study investigating the role of visual and proprioceptive information in movement demonstrated that the brain relies on visual information when planning movements, but in the absence of visual feedback during movement, it uses proprioceptive information to correct potential deviations or errors (Bagesteiro et al., 2006). In a different study, it was shown that when proprioceptive information was disrupted through tendon vibration, the accuracy and precision of arm movements were impaired even in the presence of visual information (Goodman & Tremblay, 2018). Studies investigating the relationship between proprioception and visual information in literature indicate that proprioception plays a regulatory role when visual feedback is absent, while also maintaining its importance even when visual feedback is present. However, it is important to note that the participants in this study were healthy individuals. In our study, since participants' visual information was not obstructed and there were no health issues that would completely impair the proprioceptive system (such as sensory nerve damage), no relationship may have been found between shooting performance and proprioception.

Other findings related to proprioception in our study include the association between increased plank duration and enhanced shoulder proprioception. The muscles around the shoulder, which are active during load transfer to the upper extremity, are important not only for stabilization but also for proprioception. However, the density of muscle spindles can vary depending on the mechanical properties and function of the muscle. Therefore, the quality of proprioception should be evaluated not only in terms of stabilization level but also together with the functional behaviour of the muscle (Kissane et al., 2022; Uhl et al., 2003). This relationship should therefore be interpreted with caution.

The limitation of this study is related to the assessment of proprioception. Although the joints in the upper extremity are in continuous and dynamic use during shooting performance, proprioception was evaluated using a single, static reference range of motion for each joint. This approach may not fully reflect the complex and functional nature of joint proprioception during actual performance. Although both upper extremities are used during shooting, proprioception was assessed only in the dominant upper extremity in this study. Therefore, this limitation should be considered when interpreting the proprioceptive outcomes of the study. Another limitation of this study is that different variables, which may be associated with shooting performances, such as arm length, visual attention, and upper extremity muscle strength, were not included in assessments in the study. Participants who had been playing basketball for more than one year were included in the study. However, in the analysis, basketball experience was defined as the duration after joining a sports club. We considered the time spent training under professional coaches to be a more accurate reflection of skill development. Nevertheless, from different perspectives, this approach could be considered a limitation of the study. The absence of sex-based subgroup analyses is another limitation of the present study. Since the participants were unevenly distributed (28 females and 10 males), comparisons between sexes could not be performed. Future research should consider examining sex-related differences to provide a more comprehensive understanding of these relationships.

CONCLUSIONS

The results of this study indicate that improvements both the free throw and the turn-around jump shot techniques in child basketball players are associated with increases in lower extremity explosive muscle strength and core muscle performance. Moreover, while the improvement in free throw performance was found to be associated with an increase in body height, the improvement in turn-around jump shot performance was associated with longer basketball experience. Thus, if the goal is to enhance shooting technique performance in child basketball players, assessments and exercise approaches targeting lower extremity explosive strength and core muscle endurance may be beneficial. In addition, body height and basketball playing experience should be taken into consideration.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation and data collection analysis were performed by L.N.G., and S.B.Ç. Analysis was performed by O.K. The first draft of the manuscript was written by O.K. and all authors commented on previous versions of the manuscript. All authors contributed by drafting the manuscript and/or critically revising it for important intellectual content. All authors read and approved of the final manuscript. All authors take responsibility for the work and will help resolve any issues about its accuracy or integrity.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICS APPROVAL

Prior to the study, ethical approval was obtained from the KTO Karatay University Ethics Committee (Date: May 8, 2025; Decision No: 2025/007).

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