

Relationship between decision-making and selected strength and speed abilities in elite female volleyball players

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Abstract

Introduction: This study aimed to examine the relationship between selected motor abilities and decision-making abilities in elite female volleyball players. **Material and methods:** The research sample consisted of 11 players from the top Slovak volleyball league (mean age 23.5 ± 4.2 years; sport age 12.3 ± 4.7 years). Motor abilities were assessed using tests of lower-limb explosiveness (Drop Jump, Countermovement Jump, Countermovement Jump with Arm Swing), upper-limb explosiveness (Bench Press), agility (Offensive Agility, Defensive Agility), and 5m acceleration. Decision-making abilities were assessed using the Decision-Making Index (DMI), developed through expert evaluation of 15 offensive and defensive game situations from video recordings of the 2023/2024 season by two experts. **Results:** Correlation analysis revealed several statistically significant relationships, with DMI negatively correlated with parameters of lower-limb explosive strength: DJ ($r = -0.701$; $p = 0.008$), CMJ ($r = -0.578$; $p = 0.031$), and CMJS ($r = -0.633$; $p = 0.018$). Regression analysis using the ENTER method explained 31.8% of DMI variability (Adjusted $R^2 = 0.318$), with no statistically significant predictors. The STEPWISE method identified DJ as the only significant predictor of DMI (Beta = -0.701 ; $p = 0.016$), with the regression model explaining 43.5% of the variability in DMI. **Discussion:** DMI was significantly negatively associated with lower-limb explosive strength, with DJ emerging as the only significant predictor explaining 43.5% of its variability. These findings suggest that greater explosiveness does not necessarily correspond to better decision-making performance. **Conclusions:** The relationship between motor abilities and decision-making in elite volleyball is not straightforward, as higher explosiveness may not enhance cognitive performance in game situations. Integrated physical and perceptual-cognitive training approaches are therefore recommended.

Keywords: volleyball, motor abilities, decision-making index, performance analysis

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Introduction

Players in elite volleyball are required to possess not only advanced technical and tactical skills, but also the ability to make fast and accurate decisions under pressure, as they are continuously exposed to dynamic and unpredictable game conditions. The combination of physical and perceptual-cognitive aspects is becoming more significant in modern volleyball as both are necessary for successful performance in real-game situations (Ilić et al., 2023). The performance of volleyball-specific motions requires motor skills, which are important determinants of sports success. Players can react quickly to dynamic situations and execute fundamental acts like spiking, blocking, and defensive movements thanks to key skills including acceleration, agility, and explosiveness (Ziv & Lidor, 2010; Sattler et al., 2015). Although these abilities are essential for efficient movement execution, they do not adequately explain performance results in intricate, game-like settings where perceptual-cognitive processes are crucial (Conejero Suárez et al., 2020b; Trecroci et al., 2021).

Volleyball is an open-skill sport where players must adapt and make decisions due to changing circumstances (Gökçe et al., 2022). In real time, players must be able to recognize relevant information, predict the behaviors of their opponents, and select the most effective option for action. This emphasizes the significance of perceptual-cognitive abilities, such as situational awareness, visual search, and anticipation, which have been shown to differentiate experienced players from novices (Afonso et al., 2012; Fortin-Guichard et al., 2020).

Decision-making is therefore considered a key component of performance and is increasingly viewed as a trainable component in team sports. Previous studies have demonstrated that interventions such as video-based training and game-based approaches can significantly improve players' decision-making performance (Conejero Suárez et al., 2020a; De Waelle et al., 2025). However, the applicability of these improvements to realistic game situations is still limited. These findings suggest that decision-making is highly context-dependent and influenced by multiple interacting factors.

From a theoretical perspective, decision-making is an essential component of a coherent system of perception and action rather than an independent cognitive process. According to this approach, behavior results from continuous interactions between the athlete and the environment, where perception and action are intertwined and cannot be examined independently (Araújo et al., 2023).

The relationship between cognitive and physical components of performance is a topic of increasing interest, although empirical results remain inconsistent. According to some research, higher levels of physical condition can improve cognitive abilities such as attention and information processing speed (Chang et al., 2012; Singh et al., 2025). However, these benefits seem to be task-specific and context-dependent (Garrett et al., 2024). Higher levels of motor skills do not always translate into better decision-making performance, as confirmed by research showing that the relationship between motor and cognitive performance is complex and may not be linear (Vestberg et al., 2012; Scharfen & Memmert, 2021).

Specifically in volleyball, it has been shown that perceptual and cognitive abilities are important factors in making effective decisions. Experienced players are able to process relevant information more rapidly and accurately due to their superior anticipatory abilities and more effective visual search tactics (Fortin-Guichard et al., 2020). Furthermore, targeted practice and sport-specific experience appear to be crucial for the development of decision-making abilities, indicating that physical performance alone may not be sufficient to make the optimal decisions in demanding game scenarios (Zhu et al., 2024; Seidel-Marzi et al., 2025).

Despite these findings, there is still a lack of studies specifically examining the connection between certain motor skills and decision-making ability, especially in elite female volleyball players. Most existing studies have examined the physical and cognitive domains separately, paying only marginal attention to their interaction in ecologically valid, game-based conditions (Travassos et al., 2013; Araújo et al., 2023; Conejero Suárez et al., 2020a).

The aim of this study was to examine the relationship between decision-making and selected motor skills in elite female volleyball players.

Material and methods

The research sample consisted of 11 players from the top Slovak women's volleyball league (mean age 23.5 ± 4.2 years; sport age 12.33 ± 4.7 years). The sample included players from various positions: setters (2), outside hitters (3), middle blockers (2), opposites (2), and liberos (2). Data was collected during the 2023/2024 season of the Niké Women's Volleyball Extra league. Players and evaluators were informed about the study objectives before data collection. Players were instructed on the proper execution of motor tests, and evaluators were trained to ensure consistency in completing evaluation forms based on video recordings.

Lower-limb explosive strength was tested using the OptoJump Next system (Microgate), consisting of two sensor bars placed 3 meters (m) apart on a flat surface. Three standardized tests were performed: Drop Jump (DJ), focused on eccentric and reactive strength; Countermovement Jump (CMJ); and Countermovement Jump with Arm Swing (CMJS). CMJ and CMJS primarily assess vertical lower-limb explosive power, with CMJS involving arm movement to enhance jump height. Jump height was measured in centimeters (cm). Each player performed two measured attempts in DJ and three in CMJ and CMJS, with the best result included in the analysis. These tests are among the most widely used and reliable indicators of explosive strength in volleyball (Markovic et al., 2004; Sattler et al., 2015).

Upper-limb explosive strength was measured using the TENDO MyUnit (TENDO) device, with a sensor attached to the end of an Olympic barbell. A bench press (BP) test was performed using 50% of each player's body weight. Each player completed 2 sets of 3 repetitions with a 2-minute rest interval. The best performance (measured as bar velocity in m/s) was included in the analysis, directly reflecting the ability to generate explosive upper-limb power. This approach is commonly used in volleyball strength-speed training and has demonstrated high reliability (Pereira et al., 2015).

Acceleration (A5m) over a 5 m distance was tested using the Witty SEM system (Microgate). Timing gates were positioned at the start and finish lines 5 m apart. Each player performed two timed trials, with the best result included in the analysis. Results were recorded in seconds (s). Short sprints (e.g., 5 m) are widely used and valid measures of acceleration in team sport athletes (Murphy et al., 2003).

Agility was assessed using two modified reactive agility tests with visual stimuli, also conducted with the Witty SEM system (Microgate). Offensive Agility (OA): The player simulated an attacking volleyball movement, starting 3 m away from three sensors (straight ahead, $+45^\circ$, and -45°). Upon a visual signal, the player sprinted to the indicated sensor, touched it, and returned to the starting position. Each player responded to 8 stimuli. Defensive Agility (DA): The player simulated a defensive movement, starting 3 m away from left and right sensors. Upon a visual signal, the player performed a lateral shuffle to the designated sensor, touched it, and returned. Each player responded to 8 stimuli. Times were recorded in s. Reactive tests with stimuli are considered more ecologically valid than traditional change-of-direction tests without stimuli (Sheppard & Young, 2006). The modified tests in this study account for the specific movement demands of volleyball.

Decision-making abilities were evaluated using rating sheets based on video recordings of five competitive matches from the top Slovak women's volleyball league. Two independent experts analyzed 15 randomly selected offensive and defensive actions. Only players who had participated in at least one full set to

25 points were included. Decisions were classified as appropriate or inappropriate and rated using a 5-point evaluation scale (Table 1). Expert ratings focused solely on the adequacy of decisions in the context of the game situation, regardless of execution success. The matches followed official FIVB (2016) rules in a 6x6 format and were recorded using a SONY® HDR-CX380 digital camera. The Decision-Making Index (DMI) was calculated separately for each technical skill using the formula proposed by Oslin, Mitchell, and Griffin (1998). Where: *av* = appropriate action, *an* = inappropriate action

$$DMI = \frac{(av + 10)}{(av + 10) + (an + 10)}$$

Table 1. Classification and Evaluation of Players' Decisions in Volleyball

Category	Description	Points
Appropriate Decisions		
Exceptional Decision	The player made a decision that maximally contributed to the team's advantage, effectively utilizing all available options.	5
Very Good Decision	The player's decision substantially increased the team's chance of success, though in some cases an alternative option could have been more effective.	4
Good Decision	The player's decision was correct and contributed to success but was not maximally effective in all aspects.	3
Average Decision	The player made a generally adequate decision, but its effectiveness was limited by other circumstances.	2
Weak Decision	The players' decision had a positive influence on team play but was clearly less effective compared to other available options.	1
Inappropriate Decision		
Very Poor Decision	The player's decision significantly worsened the team's situation or resulted in the loss of a point.	5
Poor Decision	The player's decision negatively affected team play but did not have a decisive impact on the rally outcome.	4
Inappropriate Decision	The player made a decision with a minor negative impact on play, without directly affecting the team's chance of success.	3
Suboptimal Decision	The player's decision was not optimal but did not influence the rally outcome or lead to a point loss.	2
Insufficient Decision	The player made a suboptimal decision that did not significantly affect the team's situation or the rally outcome.	1

The results are presented as mean $\pm$ SD and range, representing the central tendency and variability of the data. The normality of the datasets was verified using the Shapiro–Wilk normality test and visual inspection. Transformation of primary data was performed using the reversion method to the values $X_r = \max(x) - x$, where X is the original value and $\max(x)$ is the highest value in the dataset. Relationships between variables were evaluated using Spearman's correlation (motor factors and DMI). The strength of the correlation coefficient was described according to Hopkins (2009). An r value between 0 and 0.30 or 0 and –0.30 was considered small; between 0.31 and 0.49 or –0.31 and –0.49 moderate; between 0.50 and 0.69 or –0.50 and –0.69 large; between 0.70 and 0.89 or –0.70 and –0.89 very large; and between 0.90 and 1 or –0.90 and –1 almost perfect for predicting relationships. Multiple regression analysis was used to estimate the best predictive model of DMI.

Coefficients of determination (R^2) and the standard error of estimate were used to express the quality of the predictive models, with lower-limb strength and agility measures serving as independent variables and the Decision-Making Index (DMI) as the dependent variable. The level of statistical significance was set at $p \leq 0.05$ for all statistical analyses unless otherwise stated. All statistical analyses were processed using IBM SPSS 20.0 (Chicago; IBM Corporation, NY, USA).

Results

The relational analysis (Table 2) revealed several mutual relationships between the observed motor abilities and the DMI indicator. The primary relationships between DMI and selected motor variables showed that DMI was significantly negatively correlated with parameters of lower-limb explosive strength: DJ ($r = -0.701$; $p = 0.008$), CMJS ($r = -0.633$; $p = 0.018$), and CMJ ($r = -0.578$; $p = 0.031$). These represent strong to moderately strong negative relationships that can be considered statistically significant.

Among the secondary relationships, very strong correlations were confirmed between the individual indicators of lower-limb explosive strength: DJ – CMJ ($r = 0.858$; $p < 0.001$), DJ – CMJS ($r = 0.914$; $p < 0.001$), and CMJ – CMJS ($r = 0.848$; $p < 0.001$), confirming a high level of interconnection among these parameters. A moderately strong positive correlation was also found between CMJ and OA ($r = 0.573$; $p = 0.033$).

Table 2. Correlation Analysis

		DMI	A5m	OA	DA	DJ	CMJ	CMJS	BP
Spearman Correlation	DMI	1,000	0,024	-0,181	-0,105	-0,701	-0,578	-0,633	0,278
	A5m	0,024	1,000	-0,005	-0,036	0,137	0,087	0,228	0,117
	OA	-0,181	-0,005	1,000	-0,093	0,404	0,573	0,448	0,447
	DA	-0,105	-0,036	-0,093	1,000	-0,159	-0,187	-0,311	-0,372
	DJ	-0,701	0,137	0,404	-0,159	1,000	0,858	0,914	-0,287
	CMJ	-0,578	0,087	0,573	-0,187	0,858	1,000	0,848	-0,076
	CMJS	-0,633	0,228	0,448	-0,311	0,914	0,848	1,000	-0,035
	BP	0,278	0,117	0,447	-0,372	-0,287	-0,076	-0,035	1,000
Sig. (1-tailed)	DMI	.	0,472	0,298	0,379	0,008**	0,031*	0,018*	0,204
	A5m	0,472	.	0,494	0,458	0,344	0,400	0,250	0,366
	OA	0,298	0,494	.	0,393	0,109	0,033	0,084	0,084
	DA	0,379	0,458	0,393	.	0,320	0,291	0,176	0,130
	DJ	0,008**	0,344	0,109	0,320	.	0,000	0,000	0,196
	CMJ	0,031*	0,400	0,033*	0,291	0,000**	.	0,000	0,412
	CMJS	0,018*	0,250	0,084	0,176	0,000**	0,000**	.	0,459
	BP	0,204	0,366	0,084	0,130	0,196	0,412	0,459	.

DMI = Decision-Making Index; A5m = Acceleration over 5 meters; OA = Offensive Agility; DA = Defensive Agility; DJ = Drop Jump; CMJ = Countermovement Jump; CMJS = Countermovement Jump with Arm Swing; BP = Bench Press; Sig. (1-tailed) = one-tailed p-value; * $p < 0.05$; ** $p < 0.01$

The linear regression analysis using the ENTER method (Table 3) examined the influence of all monitored motor abilities (A5m, OA, DA, DJ, CMJ, CMJS, BP) on the Decision-Making Index (DMI). The adjusted coefficient of determination (Adjusted $R^2 = 0.318$) indicates that the regression model explains 31.8% of the variability of the dependent variable (DMI).

Table 3. Linear Regression Analysis – ENTER Method

Model Summary ^b									
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig. F Change
1	0,778 ^a	0,605	0,318	0,10044	0,605	0,655	7	3	0,710

a. Predictors: (Constant) A5m, OA, DA, DJ, CMJ, CMJS, BP

b. Dependent Variable: DMI

R = multiple correlation coefficient; R^2 = coefficient of determination; Adjusted R^2 = adjusted coefficient of determination; Std. Error of the Estimate = standard deviation of the residuals; R^2 Change = change in the coefficient of determination; F Change = F -statistic testing the change in explained variance; df1 = numerator degrees of freedom; df2 = denominator degrees of freedom; Sig. F Change = p -value associated with the F Change statistic

Table 4 presents the results of multiple linear regression analysis using the ENTER method, with DMI as the dependent variable and all monitored motor abilities as predictors. None of the coefficients were statistically significant ($p > 0.05$), although the relatively strongest effect was observed for DJ (Beta = -0.746).

Table 4. Coefficients of Multiple Regression – ENTER Method

Coefficients ^a												
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error				Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1(Constant)	1,538	0,605		2,544	0,084	-0,386	3,462					
A5m	0,153	0,301	0,201	0,509	0,646	-0,804	1,110	0,024	0,282	0,185	0,848	1,179
OA	0,014	0,029	0,315	0,497	0,653	-0,078	0,107	-0,181	0,276	0,180	0,327	3,058
DA	-0,050	0,064	-0,357	-0,789	0,488	-0,253	0,152	-0,105	-0,415	-0,287	0,644	1,554
DJ	-0,016	0,028	-0,746	-0,556	0,617	-0,106	0,075	-0,701	-0,306	-0,202	0,073	13,666
CMJ	0,000	0,020	-0,013	-0,015	0,989	-0,065	0,065	-0,578	-0,009	-0,006	0,187	5,359
CMJS	-0,005	0,024	-0,247	-0,203	0,852	-0,083	0,073	-0,633	-0,116	-0,074	0,089	11,216
BP	0,000	0,001	-0,243	-0,349	0,750	-0,005	0,004	0,278	-0,198	-0,127	0,271	3,685

a. Dependent Variable: DMI

B = unstandardized regression coefficient; Std. Error = standard error of B ; Beta = standardized regression coefficient; t = t -statistic testing the significance of B ; Sig. = p -value; 95% CI = 95% confidence interval for B ; Zero-order = bivariate correlation; Partial = partial correlation; Part = semi-partial correlation; Tolerance = proportion of variance in a predictor not explained by other predictors; VIF = variance inflation factor

The linear regression analysis using the STEPWISE method (Table 5) identified, through stepwise selection, eccentric lower-limb strength (DJ) as the primary explanatory predictor of DMI. The adjusted coefficient of determination (Adjusted $R^2 = 0.435$) indicates that the regression model with DJ as the predictor explains 43.5% of the variability of the dependent variable (DMI).

Regression equation: $\hat{Y} = 0.015X_1$

Table 5. Linear Regression – STEPWISE Method

Model	Model Summary ^b								
	R	R ²	Adjusted R ²	Std. Error of the Estimate	R ² Change	F Change	df1	df2	Sig. F Change
1	0,701 ^a	0,491	0,435	0,06576	0,491	8,698	1	9	0,016

a. Predictors: (Constant) DJ

b. Dependent Variable: DMI

R = multiple correlation coefficient; *R*² = coefficient of determination; Adjusted *R*² = adjusted coefficient of determination; Std. Error of the Estimate = standard deviation of the residuals; *R*² Change = change in the coefficient of determination; *F* Change = *F*-statistic testing the change in explained variance; *df*1 = numerator degrees of freedom; *df*2 = denominator degrees of freedom; Sig. *F* Change = *p*-value associated with the *F* Change statistic

Table 6 shows that the STEPWISE method identified eccentric lower-limb strength (DJ) as the main explanatory predictor of DMI. The coefficient Beta (−0.701) and the *p*-value = 0.016 confirm a strong negative relationship between DJ and DMI, with the model constant equal to 1.254.

Table 6. Coefficients – STEPWISE Method

Model	Coefficients ^a											
	Unstandardized Coefficients	Standardized Coefficients	95,0% Confidence Interval for B		Correlations		Collinearity Statistics					
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1(Constant)	1,254	0,192		6,515	0,000	-0,818	1,689					
DJ	0,015	0,005	-0,701	-2,949	0,016	-0,026	-0,003	-0,701	-0,701	-0,701	1,000	1,000

a. Dependent Variable: DMI

B = unstandardized regression coefficient; Std. Error = standard error of *B*; Beta = standardized regression coefficient; *t* = *t*-statistic testing the significance of *B*; Sig. = *p*-value; 95% CI = 95% confidence interval for *B*; Zero-order = bivariate correlation; Partial = partial correlation; Part = semi-partial correlation; Tolerance = proportion of variance in a predictor not explained by other predictors; VIF = variance inflation factor

Discussion

The aim of this study was to examine the relationship between decision-making and selected motor skills in elite female volleyball players. The primary finding was a significant negative correlation between lower-limb explosive strength and DMI (DJ: $r = -0.701$; $p = 0.008$; CMJS: $r = -0.633$; $p = 0.018$; CMJ: $r = -0.578$; $p = 0.031$). Considering the definition of DMI, where higher values indicate better decision-making ability, these negative correlations suggest that players with higher explosive jumping power tend to achieve lower DMI scores, i.e., poorer decision-making ability.

The secondary relationships revealed very strong correlations between individual indicators of lower-limb explosive strength (DJ – CMJ: $r = 0.858$; $p < 0.001$), (DJ – CMJS: $r = 0.914$; $p < 0.001$) and (CMJ – CMJS: $r = 0.848$; $p < 0.001$), confirming a high degree of interrelationship between these parameters. A moderately strong positive correlation was also found between CMJ and OA ($r = 0.573$; $p = 0.033^*$), suggesting that vertical explosiveness may be associated with a better ability to perform offensive movements in volleyball.

The regression analysis further supports these findings. The ENTER model explained approximately 32% of the variability in DMI (Adjusted $R^2 = 0.318$); although it was not statistically significant (Sig. *F* Change = 0.710). In contrast, the Stepwise model identified DJ as the only significant predictor (Beta = −0.701; $p = 0.016$), explaining 43.5% of the variability in DMI (Adjusted $R^2 = 0.435$). This result indicates that eccentric lower-limb strength is the strongest motor-related factor associated with decision-making, with higher DJ values linked to lower DMI scores.

These findings align with research indicating the absence of a direct correlation between cognitive and physical performance. For example, Hill et al. (2023) reported that athletes with varying levels of physical fitness did not differ in cognitive performance, suggesting that motor skills alone cannot explain decision-making or executive functions. This corresponds with our results, in which no positive correlation was observed between explosive strength and decision-making performance.

Similarly, Horníková et al. (2025) found a significant negative correlation between CMJ and reactive agility ($r = -0.744$; $p < 0.001$) among adolescent soccer players, suggesting that higher explosive strength may be linked to worse performance in tasks requiring quick decision-making. These results are in close agreement with the current findings and provide credence to the idea that improved neuromuscular ability does not always translate into more effective decision-making in dynamic game scenarios.

Additional data indicates that success in tasks involving decision-making can only be partially explained by physical abilities. The limited explanatory significance of physical elements alone is highlighted by studies on reactive agility, which demonstrate that motor components account for around 38% of performance variation while cognitive components contribute about 32% (Horníková & Skala, 2025). This may explain why higher explosive strength in the present study was not associated with better decision-making outcomes.

According to Manninen et al. (2024), game-based training significantly improved decision-making abilities while having minimal impact on motor skills, suggesting that the development of decision-making abilities is not largely dependent on physical performance. Likewise, Silva et al. (2023) found that decision-making scores improved as a result of a multivariate training program that included technical, tactical, and cognitive elements without prioritizing physical growth. These results indicate that improving isolated motor skills is less important for decision-making than the specificity of training and perceptual-cognitive stimulation.

This interpretation is further supported by Conejero Suárez et al. (2020a), who observe in their meta-analysis that training programs centered on decision-making considerably increase performance regardless of physical characteristics. These studies indicate that the quality of decision-making is fundamentally contingent upon the capacity to perceive and interpret game situations, rather than solely on physical condition.

Conclusion

This pilot study provides initial evidence that the relationship between decision-making and selected motor skills in elite volleyball is not straightforward. The negative correlations between Decision-Making Index and parameters of lower-limb explosive strength (DJ, CMJ, CMJS) suggest that higher levels of explosiveness do not necessarily lead to better decision-making in game situations. This relationship may be influenced by players' specialization in different playing positions, varying levels of cognitive preparedness, and methodological limitations.

The main limitation of this study is the small sample size ($n = 11^*$), which limits the statistical power and generalizability of the findings. Nevertheless, the results highlight the importance of integrated training approaches that combine physical and perceptual-cognitive elements, rather than focusing on motor skills in isolation.

These findings also contribute to the understanding of the interaction between cognitive functions and athletic performance, an area that remains under-researched in women's volleyball. From a practical perspective, incorporating cognitive assessment alongside physical, technical, and tactical evaluation may support a more comprehensive approach to talent identification and athlete development.

Future research should include larger samples and longitudinal designs to better clarify the relationship between decision-making and motor skills in sport-specific contexts.

In summary, although explosive power is an important aspect of volleyball performance, it does not necessarily translate into better decision-making and may, in certain contexts, be associated with reduced decision-making efficiency.

Conflict of Interest

All authors in this study declare that they have no conflict of interest with any party.

Declaration of generative AI and AI-assisted technologies in the writing process

In the preparation of this manuscript, AI-powered tools were used exclusively for proofreading and grammatical corrections.

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