Supplementary Material. *Analysis of Decisive Penalty Kick T-Patterns*

A pattern search was conducted targeting sequences with a minimum of three occurrences, resulting in the identification of 2,435 distinct patterns. The initial selection criterion was the type of decisive penalty kick, categorized as miss-lose , score-win , or miss followed by opponent scoring—resulting in a loss. Within each of these categories, patterns were further classified based on the kicker's laterality—left-footed or right—footed . Finally, the outcome of the penalty was considered, distinguishing whether it resulted in a goal, a save by the goalkeeper, or the ball going out.

The following table (Table S1) presents the results of a T-pattern analysis conducted on decisive penalty kicks that, when missed, directly resulted in the elimination of the kicking team (miss-lose).

Table S1. T-Patterns in Miss-Lose Penalties

Pattern Type	O	L	%
(miss-lose; left footed)	***13***	***2***	***100***
((miss-lose; second turn)(left footed; long run))	9	4	*69.2*
(((miss-lose; second turn)(left footed; long run)) goal)	7	5	*53.8*
(((miss-lose; second turn)(left footed; long run))(right-down; goal))	3	6	*23.1*
(miss-lose; right footed)			
(miss-lose (right footed; goal))	***30***	***3***	***100***
(miss-lose ((second turn; right footed)(long run; goal)))	16	5	*53.3*
((neutral stadium ((miss-lose; second turn)(right footed; long run))) goal)	11	6	*36.6*
(((neutral stadium; miss-lose)(right footed; long run))(left-down; goal))	6	6	*20*
(miss-lose (second turn ((right footed; long run)(left-down; goal))))	5	6	*16.7*
(((miss-lose; first turn)(right footed; long run))(left-down; goal))	5	6	*16.7*
((neutral stadium ((quarter finals; miss-lose)(right footed; long run))) goal)	8	6	*26.6*
((neutral stadium ((quarter finals; miss-lose)(first turn; right footed)))(long run (left-down; goal)))	3	8	*10*
(((neutral stadium; final)(miss-lose (right footed; long run))) goal)	9	6	*30*
(((neutral stadium; final)((miss-lose; second turn)(right footed; long run))) goal)	6	7	*20*
((neutral stadium; final)((miss-lose (second turn; right footed))(long run (left- medium height; goal))))	3	8	*10*
(((miss-lose; second turn)(right footed; long run)) out)	***6***	***5***	***100***
(neutral stadium ((quarter finals; miss-lose)((second turn; right footed)(long run; out))))	3	7	*50*
(miss-lose (right footed; save))	***8***	***3***	***100***
((miss-lose; right footed)(long run; save))	7	4	*87.5*
(miss-lose ((right footed; long run)(right down; save)))	3	5	*37.5*

The T-pattern analysis revealed that, among left-footed players in Miss-Lose penalty kick situations (13), most penalties were taken during the second turn (69.2%), with a long run-up (69.2%). Most of these attempts resulted in a goal (53.8%) and were predominantly directed toward the lower-right zone of the goal (23.1%).

T-pattern analysis of right-footed players whose penalty kicks resulted in goals (30) indicated that most penalties were taken during the second round (53.3%), with a long run-up (53.3%), and aimed at the lower-left zone of the goal (16.7%). Additionally, these penalties were executed in neutral stadiums (10%) and during the quarterfinal round (10%).

Regarding T-patterns for right-footed players whose penalty kicks resulted in misses out of bounds (6), all were taken during the second turn with a long run-up. Furthermore, these penalties were predominantly executed in the quarterfinals (50%) and at neutral stadiums (50%).

Finally, T-pattern analysis of right-footed players whose penalty kicks were saved (8) revealed that most attempts involved a long run-up (87.5%) and were directed toward the lower-right zone of the goal (37.5%).

Table S2 presents the results of a T-pattern analysis conducted on decisive penalty kicks that, when scored, immediately secured victory for the kicking team (score-win).

Table S2. T-Patterns in Score-Win Penalties

Pattern Type	O	L	%
(score-win; left footed)	***18***	***2***	***100%***
((score-win; left footed)(long run; goal))	14	4	*77.8*
(neutral stadium (quarter finals ((score-win; left footed)(long run; goal))))	6	6	*33.3*
((neutral stadium; quarter finals)((score-win; left footed)(long run (right-down ; goal))))	3	7	*16.7*
(score-win; right footed)			
(score-win (right footed; goal)	***34***	***3***	***100%***
(score-win ((second turn; right footed)(long run; goal)))	21	5	*61.8*
((neutral stadium; score-win)((second turn; right footed)(long run; goal)))	17	6	*50*
((neutral stadium ((score-win; second turn)(right footed; long run)))(left-down; goal))	7	7	*20.6*
((neutral stadium ((round of 16; score-win)(second turn; right footed)))(long run (left-down; goal)))	3	8	*8.8*
(((final; score-win)(right footed; long run)) goal)	8	5	*23.5*
(((neutral stadium; final)((score-win; second turn)(right footed; long run))) goal)	5	7	*14.7*
(score-win ((second turn; right footed)(long run; out)))	***6***	***5***	***100%***
(((score-win; second turn)(right footed; long run))(left-top; out))	4	6	*66.7*
((quarter finals ((score-win; second turn)(right footed; long run)))(left-top; out))	3	7	*50*
(score-win; right footed; save)	**0**	**0**	

In left-footed players during score-win penalties (18), the majority ended in a goal (77.8%), involved a long run-up (77.8%), and were performed in neutral stadiums (33.3%) as well as during the quarterfinals (33.3%). Additionally, 16.7% of these penalties were directed toward the lower-right zone of the goal.

For right-footed players in score-win penalties resulting in goals (34), T-pattern analysis indicated that these attempts commonly occurred in the second round (61.8%), with a long run-up (61.8%), at neutral stadiums (50%), and aimed at the lower-left zone of the goal (20.6%). Notably, 8.8% of these penalties took place during the round of 16.

Regarding right-footed players whose penalty kicks went out of bounds (6), all were taken in the second turn (100%) with a long run-up (100%), predominantly aimed at the upper-left zone (66.7%) and often occurring during the quarterfinals (50%).

The following table (Table S3) presents the results of a T-pattern analysis conducted on decisive penalty kicks that, when missed, did not result in immediate elimination but gave the opposing team the chance to win in the next round (miss-continue).

Table S3. T-Patterns in Miss-Continue Penalties

Pattern Type	O	L	%
(miss-continue; left footed)	***18***	***2***	***100%***
((miss-continue; left footed)(long run; goal))	11	4	*61.1*
(((miss-continue; first turn)(left footed; long run)) goal)	7	5	*38.9*
(((visitor; round of 16)(miss-continue; first turn))(left footed (long run; goal)))	3	7	*16.7*
(miss-continue; right footed)			
(miss-continue (right footed (long run; goal)))	***43***	***4***	***100%***

((miss-continue; first turn)(right (long run; goal)))	29	5	*67.4*
(neutral stadium ((miss-continue; first turn)(right footed (long run; goal))))	23	6	*53.5*
((neutral stadium ((miss-continue; first turn)(right footed; long run)))(right footed; goal))	4	7	*9.3*
((neutral stadium ((miss-continue; first turn)(right footed; long run)))(left-down; goal))	6	7	*13.9*
(((neutral stadium; quarter finals)((miss-continue; first turn)(right footed; long run))) goal)	9	7	*20.9*
(((neutral stadium; quarter finals)((miss-continue; first turn)(right footed; long run)))(left-top; goal))	3	8	*7*
(((final; miss-continue)(right footed; long run)) goal)	9	5	*20.9*
((neutral stadium; final)((miss-continue; first turn)(right footed (long run; goal))))	8	7	*18.6*
(miss-continue (right footed (long run; out)))	***11***	***4***	***100%***
(((neutral stadium; miss-continue)(right footed; long run)) out)	8	5	*72.7*
(((neutral stadium; miss-continue)(right footed; long run))(left-down; out))	3	6	*27.3*
((neutral stadium ((miss-continue; first turn)(right footed; long run))) out)	5	6	*45.5*
((miss-continue (right footed; long run)) save)	***23***	***4***	***100%***
((neutral stadium ((miss-continue; second turn)(right footed; long run))) save)	8	6	*34.8*
((neutral stadium ((miss-continue; second turn)(right footed; long run)))(right-down; save))	5	7	*21.7*
((miss-continue; first turn)(right footed (long run; save)))	12	5	*52.2*
(miss-continue ((first turn; right footed)(long run (left-medium height; save))))	4	6	*17.4*
(miss-continue ((first turn; right footed)(long run (left-down; save))))	4	6	*17.4*

In penalty kicks where a miss leaves the opponent in a position to win if they score, T-pattern analysis of left-footed players (18) revealed that these penalties are typically executed with a long run-up (61.1%) and often result in a goal (61.1%). Additionally, it is common for these penalties to be taken in the first turn (38.9%) and during away matches (16.7%) in the round of 16 (16.7%).

Regarding right-footed players in similar high-stakes penalty scenarios that ended in goals (43), all penalties were executed with a long run-up. Most of these attempts occurred in the first turn (67.4%), with a notable frequency of neutral stadium (53.5%). Two directional tendencies were observed: penalties aimed at the lower-right zone (9.3%) and the lower-left zone (13.9%), with the latter being more common.

For right-footed players whose penalty kicks went out of bounds in situations where a miss would give the opponent a winning advantage (11), T-pattern analysis showed that all were taken with a long run-up, generally at neutral stadiums (72.7%), and primarily directed toward the lower-left zone (27.3%).

Finally, concerning right-footed players whose penalty kicks were saved by the goalkeeper in scenarios where a miss allows the opponent to continue (23), T-patterns revealed that all were taken with a long run-up, frequently during the first turn (52.2%). The most common target zones for these penalties were the lower-left (17.4%) and middle-left (17.4%) areas of the goal.