



The Practicality and Effectiveness of Soccer Scoring Techniques Revealed by Top Elite Soccer Scorers

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Abstract

Background: Although there are 43 soccer scoring techniques (SSTs) identified in the elite soccer games, most of them are overlooked by the current coaching practice. Obviously, the lack of scientific quantification on the fundamental issues related to SSTs could be one of the reasons for the crisis. Therefore, improving coaching practice requires efforts on fundamental researches to supply evidences that can be used to better guide the SST research and the development of SST training systems. Two of the fundamental aspects are the practicality and effectiveness of SSTs. The current study aims to uncover these two aspects. **Method:** All repeated nominees of the FIFA Puskás Award were selected as study subjects. The terminology system and the identification method developed by Zhang in 2021 were applied in scoring video analysis of the subjects' career goals. The percentage of goal obtained by each SST (practicality) and ball possessions before shooting for each goal (effectiveness) were determined to reveal the SSTs' practicality and shooting effectiveness of the top elite scorers. In total, 2315 goals were quantified. **Results and Conclusion:** The study has unveiled: 1) the practicality is increased if a SST can be applied in shots under all-body-orientation regardless of the ball spatial position at the instant of shooting, 2) the practicality is also associated with the SSTs that can provide either sudden change of ball motion direction at the instant of shooting or unpredictable ball flight, 3) the effectiveness is linked to shots taken with no or one setting of the ball, and 4) the practicality and effectiveness do not always go along with each other and anthropometrically-dependent characteristics should be considered in SST development. As the 1st pilot investigation on the topic, this study would supply a foundation and rich food for speculative thoughts in further explorations that aim to innovatively develop SSTs' training systems in the future.

Keyword: all-body-orientation shots, unpredictable ball flights, generalization, individualization, anthropometry.

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INTRODUCTION

The ultimate aim of soccer is to score goals. Therefore, learning and improving soccer scoring techniques (SSTs) should be the essential core of soccer training. Yet, there has been a disconnection between the soccer practice and the current SST training systems. On one side, there are 43 SSTs identified at practical level in the elite soccer games [1, 2]; while, on the other side, there are only a few SSTs, i.e. the maximal instep kick (including the curl kick), pass kick, chip/lob kick, jumping headers, and volleys (including side volleys), that can be trained in the current training systems [3-6]. The scenario suggests that the scientific understanding and SSTs training systems lags far behind soccer practice. When considering the diversity of SST and the possible ways for improving the effectiveness of current SST training systems, two fundamental questions are arising: "what are the practical SSTs often applied for scoring goals and, therefore, should be trained widely?" and "how to justify their practicality and effectiveness?". Regrettably, there are no answers available in the current literature body.

The literature on soccer scoring is crammed full of researches that identify the score possibility. The scientific identification started as early as in 1960s, quantifying the statistical relationship between the number of passes and goals scored by analyzing 3213 professional matches between 1953 and 1968 [7]. The study has revealed that approximately 80% of goals resulted from a sequence of three passes or less. Later, geographic location of shots was investigated. The related studies have shown that more than 65% of goals are scored when an attacking player possesses the ball near or inside the opponents' box, and he/she is not hindered by defenders – a "free ball" [8, 9]. Hereafter, more and more notational measurements have been developed and applied to find the factors influencing scoring. These measurements include ball possession time [10, 11], shots at goal [12], the position of an attempt on goal (e.g., from right, center, or left) [13, 14], the influence of set plays or dead ball routines [15, 16] and more. However, as reviewed in recent studies, these studies focused only on team strategies to achieve score opportunity and underemphasized the role of various SSTs in scoring [2, 6]. As a result, the consideration of investigating the role of various SSTs has attracted minimal attention from researchers and practitioners.

The above research climate has resulted in limited knowledge on how to learn/train various SSTs. Literature has shown that the SST research so far is insufficient for improving current coaching practice [2]. At present, the scientific quantification of SSTs is limited within 8 SSTs, overwhelmingly on one SST – maximal instep kick [17-20]. As a consequence, this SST is well understood and trained around the world [3-5, 21-23]. But, there are very limited papers on the other 7 SSTs studied, and for the rest of the 43 SSTs, there is still a dearth of scientific investigation [2], i.e. the existing scientific understanding could not supply enough help to practitioners in developing training methods for learning the available SSTs. This is why that there are only a handful of SSTs documented in the existing training/coaching literature [3-5], resulting in the disconnection between the soccer practice and the current SST training systems. It is understandable that the only way left for athletes to develop more SSTs is self-learning without insight knowledge obtained from scientific research. The common practice is that the exceptional SSTs developed by a few talented athletes from time to time have become models for athletes and coaches to impersonate and duplicate blindly. Scientifically, there are two issues related to such blind self-learning: learning efficiency and injury risk.

Thence, establishing a science-based SST training system is an essential way for improving learning efficiency and, at the same time, minimizing injury risk during learning/training. Given the diversity of SST, knowing the answers for the practicality and effectiveness of SSTs would build a foundation on which application-oriented SST studies could be launched and science-based training systems could be developed. Thereupon, the purpose of the current study is to supply scientifically-funded evidences for justifying the practicality and effectiveness of SSTs. The justified results would contribute to the fundamental development of effective SST learning/training systems.

MATERIAL AND METHODS

Justification concepts for SSTs practicality and effectiveness

It is well known that soccer shots are normally happened in highly dynamic situations. This complexity leads talented players having invented various SSTs to deal with diverse dynamic chances for scoring. So far, 43 SSTs have been identified at the elite level [1]. A “nature” justification of the practicality of a SST is the goal frequency of its use in real games. In this regard, top professional scorers are the most qualified sources to report on the practicality of various SSTs, because their talent enables them to have mastered more SSTs (as such more choices available for them) than most players. By examining the goals obtained at the elite level and the SSTs applied at various dynamic scoring scenarios by the elite scorers, the justification will be more eligible to provide solid evidences that can be meaningful to guiding the future SST research and developing/improving the SST training systems.

SST effectiveness is of the essence when preparing to shoot the ball. Even if in possession of a “free ball”, a player will likely not be free for long; defenders will attempt to thwart the shot. The recent study [6] examining 132 FIFA Puskás Award nominated goals between 2009 and 2021 has found that scoring with 0 possessions (a “one touch shot” where a player shoots as a ball is passing by) amounts for 56.8% of goals. Setting the ball and then shooting (1 possession) is for 13.7% of goals. Combining 0 and 1 possession shots accounts for more than 70% of goals. All other ball control strategies combined (2 or more possession maneuvers) have lower success rates. Clearly, attacks with 0 possessions have the greatest effectiveness. The results suggest that the longer a player possesses the ball, the lower the scoring chance. It should be mentioned that the FIFA Puskás Award is an award for the most aesthetically significant goal of the year and the rule is “the goal should not be the result of luck or mistakes by the other team” [24], suggesting that the nominated goals and the related SSTs are obviously repeatable, i.e. entrainable.

An additional concept linked to the practicality and effectiveness is the vertical ball positioning at the instant of shooting, i.e. a ground ball or an airborne ball. Studies have shown that the airborne shots are with high risks, as such more challenging than ground shots [25-28]. However, the study on FIFA Puskás Award nominated goals has unveiled that the air-attack SSTs are commonly applied for the one-touch-shot [6], hence, most effective.

Selection of data sources and data

Based on the above concepts, the current study selected the top scorers among the FIFA Puskás Award nominees. The only criterion for the selection was the times of nominations: two or more. Repeated nominations would indicate an outstanding SST ability. Under this criterion, four elite players were chosen (Table 1).

The data source is the public big-data bank YouTube, which contains millions of soccer scoring videos. The data collection were performed in 2020. In order to obtain a holistic and reliable evidences, all the carrier goals of the 4 candidates were collected. The details are shown in Table 2.

Data analysis

The terminology system and the identification method developed by Zhang, et al. [1] were applied in scoring video analysis for all goals and associated SSTs’ identification. The parameters obtained were: SST applied in each goal, the percentage of goal obtained by each SST for each player, ball possessions before shooting for each goal and attack type, i.e. ground- or air-attack, of each goal. These parameters were used to reveal the SSTs’ practicality and shooting effectiveness of the 4 top elite scorers. In total, 2315 goals were quantitatively analyzed. Finally, the ranking method was applied for determining the most practical SSTs with a cut-off value of 5%. Microsoft Excel V16.0 was used for the analysis.

Table 1. The 4 top elite scorers selected from the nominees of FIFA Puskás Award till 2020 [29]

Name	Nationality	Times of Nomination
Lionel Messi	Argentina	7
Neymar Jr	Brazil	5
Zlatan Ibrahimović	Sweden	4
Cristiano Ronaldo	Portugal	2

Table 2. The body height, team played and goals of the 4 top elite scorers: from their carrier begin to 2020.

Name	Body Height (m)	Team	goals	Total
Lionel Messi	1.69 [30]	FC Barcelona (2004-2020) [31]	634	704
		Argentina (2005-2020) [32]	70	
Neymar Jr	1.75 [33]	Santos FC (2009-2013) [34]	135	369
		FC Barcelona (2013-2017) [35]	105	
		Paris Saint-Germain (2017-2020) [36]	70	
		Brasil (2010-2020) [37]	59	
Zlatan Ibrahimović	1.95 [38]	Ajax (2001-2004) [39]	48	517
		Juventus (2004-2006) [40]	26	
		Inter Milan (2006-2009) [41]	66	
		FC Barcelona (2009-2011) [42]	22	
		Paris Saint-Germain (2012-2016) [43]	156	
		Manchester United (2016-2017) [44]	28	
		LA Galaxy (2018-2019) [45]	53	
		AC Milan (2010-2012 & 2019-2020) [46]	56	
Cristiano Ronaldo	1.87 [48]	Sweden (2001-2016) [47]	62	725
		Sporting Lisbon (2002-2003) [49]	5	
		Manchester United (2003-2009) [50]	118	
		Real Madrid (2009-2018) [51]	450	
		Juventus (2018-2020) [52]	53	
		Portugal (2003-2020) [53]	99	

RESULTS

The SST ability of the 4 top scorers is shown in Table 3. Among them, Ibrahimović has the highest SST ability. He is able to perform 40 SSTs for scoring, followed by Ronaldo (37 SSTs), Messi (31 SSTs) and Neymar (27 SSTs). Determined by the cut-off value: $\geq 5\%$ of individual total goals, there are 5 SSTs are sorted out for each players. Among the identified SSTs, inward instep kick and pass kick are consistently ranked as the number 1 and 2 SSTs applied for scoring for all the 4 players. The well-studied and widely-trained SST – maximal instep kick is only rated as the number 3 for 3 players: Messi, Neymar and Ibrahimović, while the Knuckleball kick is the number 3 for Ronaldo. The curl kick and chip/lob kick are the 4th and 5th often-applied SST for scoring used by Messi and Neymar, whereas the air-attack SSTs – side volley and jumping turning header – are the 4th and 5th often-applied SST by Ibrahimović, as well as the 5th and 4th one by Ronaldo. The top 5 SSTs contribute to 75.1%, 77.9%, 59.0% and 69.8% of individual total goals for Messi, Neymar, Ibrahimović and Ronaldo, respectively.

The shooting effectiveness of the 4 top elite scorers are shown in Table 4. For Messi, 44.5% of his goals scored by one-touch (i.e. zero-possession) shot, 22.5% of his goals scored after setting the ball and then shooting (i.e. one possession), and 33.0% of his goals scored by shots after more possessions/dribbling. In terms of the ball vertical position at the instant of shooting, 79.4 % of Messi goals are archived by shooting ground balls, only 20.6% of Messi goals are obtained by airborne shots.

Table 3. The SST ability, top 5 SSTs and their contributions to goals of the 4 top elite soccer scorers

Name	SST Ability	Top 5 SSTs	Ranking	Goal %	Total %
Lionel Messi	31/43	Inward instep kick	#1	31.9%	75.1%
		Pass kick	#2	20.2%	
		Maximal instep kick	#3	12.0%	
		Curl kick	#4	6.0%	
		Chip/lob kick	#5	5.0%	
Neymar Jr	27/43	Inward instep kick	#1	32.0%	77.9%
		Pass kick	#2	28.5%	
		Maximal instep kick	#3	7.3%	
		Curl kick	#4	5.1%	
		Chip/lob kick	#5	5.0%	
Zlatan Ibrahimović	40/43	Inward instep kick	#1	19.5%	59.0%
		Pass kick	#2	17.4%	
		Maximal instep kick	#3	8.9%	
		Side volley	#4	7.0%	
		Jumping turning header	#5	6.2%	
Cristiano Ronaldo	37/43	Inward instep kick	#1	22.5%	69.8%
		Pass kick	#2	18.8%	
		Knuckleball kick	#3	13.4%	
		Jumping turning header	#4	9.9%	
		Side volley	#5	5.2%	

Table 4. Shooting characteristics of the 4 top elite soccer scorers.

Name	Ball	Shooting Characteristics	Goal %	Total %
Lionel Messi	Possessions	0 (one-touch shot)	44.5%	100.0%
		1 (set-up and shot)	22.5%	
		≥2 (shot after dribbling)	33.0%	
	Vertical position	Ground	79.4%	100.0%
		Airborne	20.6%	
Neymar Jr	Possessions	0 (one-touch shot)	45.7%	100.0%
		1 (set-up and shot)	19.9%	
		≥2 (shot after dribbling)	34.4%	
	Vertical position	Ground	74.9%	100.0%
		Airborne	25.1%	
Zlatan Ibrahimović	Possessions	0 (one-touch shot)	67.9%	100.0%
		1 (set-up and shot)	17.1%	
		≥2 (shot after dribbling)	15.0%	
	Vertical position	Ground	44.2%	100.0%
		Airborne	55.8%	
Cristiano Ronaldo	Possessions	0 (one-touch shot)	66.1%	100.0%
		1 (set-up and shot)	16.9%	
		≥2 (shot after dribbling)	17.0%	
	Vertical position	Ground	47.5%	100.0%
		Airborne	52.5%	

The shooting effectiveness of Neymar show comparable results to Messi's: 45.7% of Neymar goals are scored by one-touch, 19.9% goals after one possession, and 34.4% by shots after more possessions/dribbling; as well as 74.9 % of Neymar goals are archived by ground-attacks, while 25.1% goals are scored by air-attacks.

Ibrahimović and Ronaldo demonstrate different shooting effectiveness in comparison to Messi and Neymar. For Ibrahimović, 69.7% of his goals scored by one-touch shot, 17.1% of his goals scored after one possession, and only 15.0% of his goals scored by shots after more possessions/dribbling. As for the ball vertical position at the instant of shooting, less than half (i.e. 44.2%) of his goals are archived by shooting ground balls, over half (i.e. 55.8%) of his goals are scored by airborne shots

Ronaldo shows a similar shooting effectiveness to Ibrahimović's: 66.1% of Ronaldo goals are scored by one-touch, 16.9% goals after one possession, and 17.0% by shots after more possessions/dribbling; as well as 47.5 % of Ronaldo goals are archived by ground-attacks, while 52.5% goals are scored by air-attacks.

DISCUSSION

Soccer shots, like many complicated sport movements [54-57], are trained motor skills that require trainings starting at young age and years of practice. Since there are 43 SSTs available, it would be unrealistic to learn and train all of them for most of the trainees. Thus, focused learning and training are desired by practitioners. Therefore, knowing the practicality and effectiveness of SSTs are vital for developing coaching systems that meet the needs of soccer practice. Further, studies have demonstrated that systematic & scientific inquiry into the biomechanics of human motor skills has a great potential to demystify complicated human motor skills for improving learning/training efficiency [58-61]. Unfortunately, the current study has revealed that neither the SST research nor the current SST training system could be able to supply support for improving the soccer practice. The following points drawn from this study highlight some realities and challenges for researchers and practitioners to think about how to develop science-based SST training systems.

The reality related to the current SST research and training

Notwithstanding the corroboration of some expectations, the current study has unveiled several surprising/embarrassing facts. As expected, the pass kick (the #2 in the practicality ranking list) is one of the most applied SSTs, because it is easy to learn, to perform and to control the shooting accuracy. Especially, under a free goal and a free ball situation, it is the safest choice to score a goal. The next confirmed expectation is the anthropometrical influence on sport skills [62, 63], as such on individualized SST development. This study has verified that the ground-attack SSTs are practical for the relatively short players like Messi and Neymar, while the air-attack SSTs supply more advantage for the relative tall players like Ibrahimović and Ronaldo (Table 2). The last confirmed expectation is that the higher the personal dribbling ability is, the lower the shooting effectiveness, i.e. the longer a player possesses the ball, the lower the scoring chance [2, 6]. As a matter of a fact, both Messi and Neymar are commonly known for their superb dribbling skill. Although all the 4 top elite scorers have high shooting effectiveness (combined, 0 and 1 possession shots accounts for more than 65% of goals, ranging from 65.6% to 85.0%), this study has proven that the effectiveness of Messi and Neymar (67% and 65.6%, respectively) is notably lower than that of Ibrahimović and Ronaldo (85.0% and 83.0% respectively) (Table 4).

The first surprising fact is that the most practical SST is the inward instep kick. Embarrassingly, there are neither published studies on its motor control characteristics nor documented coaching materials for its learning and training [2]. The confirmation of its practicality by the top elite scorers is a result of its highly-flexible use in diverse shooting situations. The unique characteristics of the SST will be discussed in the section below. The second surprising fact is the only well-studied and wildy-trained SST – the maximal instep kick is only ranked as the #3 for 3 top elite players and out of the top 5 SSTs for Ronaldo. The result would indicate at least a weakness existed regarding its application in soccer games. Since the maximal instep kick, from seeing, is very similar to the inward instep kick, a comparison between them will be given in the next section for discussing the hidden aspects. The last embarrassing fact is related to the current SST research. Among the identified top practical SSTs, there have been a few published papers on the skill control of the curl kick, the chip/lob kick and the knuckleball kick, even upsetting there is no full-body motor-control quantification of these SSTs. As such, an understanding of segment coordination/motor-control mechanism for these skills' learning

remains incomplete [2]. As for the jumping turning header and side volley, there is no research papers available in Web of Science [2]. These facts indicate that our knowledge on the top practical SSTs are too limited to systematically improve the current SST training systems.

The unique aspects related to practicality and effectiveness

Based on the current literature, the existing research and coaching practice emphasize on shots taken: 1) facing the goal, and 2) with the ball between the player and the goal, i.e. a between-ball facing kick [2-5]. Such a training would narrow the application range of SSTs trained. One should keep in mind that soccer games are exceedingly dynamic and the instant free-ball chance obtained will be heterogeneous. At the brief moment, an attacker's body orientation can be facing, side-facing, or back-facing, relative to the position of the goal; using the goal and the player as positional references, the ball can be between them, beyond them or to the side of them [1, 6]. Any additional setting on free-balls to the trained between-ball facing kicks will definitely miss many scoring chances. Fortunately, the top elite scorers, through their talent and rich experience, have unearthed practical SSTs for various score chances obtained. The following would be some unique aspects invented by the top elite scorers:

SSTs that can be performed under all body orientations, i.e. facing, side-facing, or back-facing to the goal

Among the 43 SSTs identified so far, there are only two SSTs possess the uniqueness [1]. They are the inward instep kick and the jumping turning header. The obvious advantages supplied by the two SSTs are their flexible applications in all body orientation scenarios and the sudden change of ball motion direction at the instant of shooting. The sudden direction change will leave insufficient time for goalkeepers to react.

Taking the inward instep kick as an example: The elite player who is famous for applying this SST is Arjen Robben [64, 65] from the Netherland (Figure 1). He has demonstrated that the skill can be applied in shots under various dynamic situations, e.g. shots during a movement toward the goal (facing), parallel to the goal (side-facing) or even away from the goal (back-facing) (Figure 2). In comparison to the maximal instep kick, one could easily understand why the widely-trained shooting skill is not as favorable/practical as the inward instep kick among top elite scorers. The apparent weaknesses of the maximal instep kick are lack of flexibility in its application, i.e. only suitable for facing kicks [19, 23], hence, with an easily-predictable ball flight [20]. When combining the inward instep kick with high dribbling ability (like Messi and Neymar), shots would become even more unpredictable, as such unstoppable. Generally, as far as players increase their kick quality (especially the kick accuracy) through training, the successful rate of the inward instep kick would be increased. In short, the flexibility of the inward instep kick makes a shot, if not possible, very difficult to predict for the goalkeeper, as such to be saved.

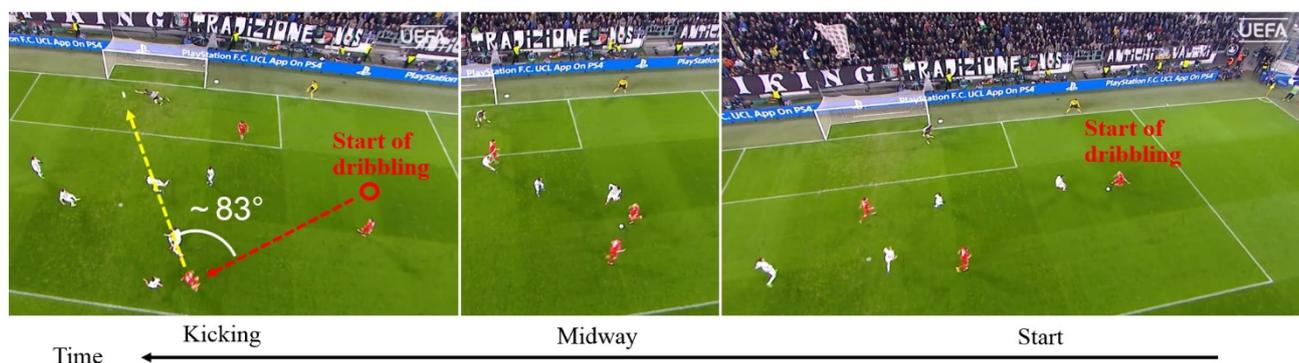


Figure 1. A successful inward instep kick performed by Arjen Robben (FC Bayern Munich) vs Juventus in 2016 (the figure was generated from the video of UEFA [64]). Red dot line: dribbling direction; yellow dot line: kicking/ball flight direction.

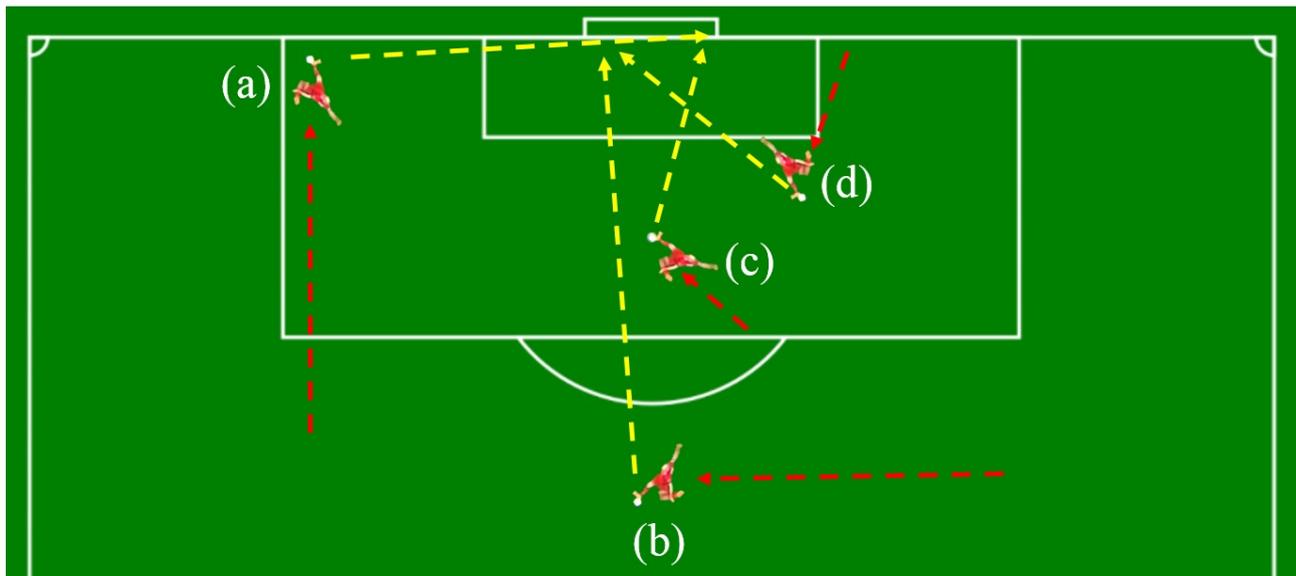


Figure 2. The common scenarios where the inward instep kicks are applied: (a) side-facing kick after dribbling toward the goal line, (b) side-facing kick after dribbling parallel to the goal line, (c) penalty kick (facing kick) and (d) back-facing kick after dribbling away from the goal line. Red dot line: dribbling direction; yellow dot line: kicking/ball flight direction.

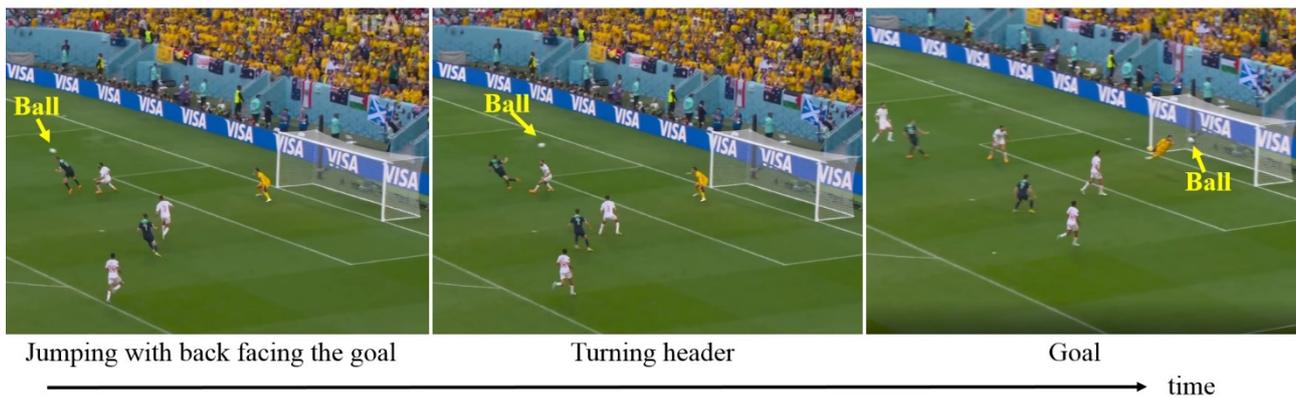


Figure 3. An exemplar beyond-ball back-facing shot achieved through the jumping turning header (the figure was generated from the video of FIFA [66]).

Regarding the jumping turning header, two more additional advantages – high effectiveness (one-touch shot) and shots under diverse ball horizontal positions (between-, side- or beyond-ball) – have been added to the SST. Integrating the flexibility of body orientation identified above, the zero-possession air-attack SST can be applied in between-ball facing shot, side-ball side-facing shot or beyond-ball back-facing shot (Figure 3). The further increased flexibility of the SST makes shot predictions as well as saves almost impossible for goalkeepers. Currently, this SST is still understudied, especially there is a research dearth on its application in beyond-ball back-facing scenario [2].

SSTs that create hard-to-predict ball flights to goalkeepers

Among the 43 SSTs identified so far, there are several SSTs that have the function. In addition to the two SSTs mention above, i.e. the inward instep kick and the jumping turning header, the curl kick and the knuckleball kick are the other two SSTs. The former can curve the ball around the defenders' wall and back into the goal, as the goalie has a very low chance of blocking the shot [2]; while the latter can generate ball wavering or dropping unpredictably during its flight (known as a “zigzag ball” in practice) [2], which is extremely difficult to judge the ball flight for goalkeepers. Cristiano Ronaldo is famous and prolific kicker of the knuckleball [67]. It should be mentioned that

many elite players are able to perform the curl kick, but a few can carry out the knuckleball kick. In short, the hard-to-predict nature makes these two SSTs more practical and useful for scoring goals in free kick situations. Both the curl kick and the knuckleball kick are understudied too [2].

SSTs that make goalkeepers powerless

There are three common dynamic scenarios where goalkeepers are powerless: 1) sudden change of the ball flight direction, 2) unpredictable ball flight, and 3) over the vertical height where goalkeepers cannot reach. The first two scenarios have been discussed above. For the 3rd scenario, the successful SST is the chip/lob kick. In a chip shot, the ball is kicked from underneath with less than maximal force to lift the ball into the air, where the goalkeeper cannot reach it, and then have it come back down again into the goal [2]. Combining with his outstanding dribbling ability, Lionel Messi has made the chip kick his trademark moves [68].

Generalization vs. individualization in SSTs development

It would be ideal that a training system can entrain players with a generally valid approach. Due to the multifaceted nature of SSTs, some SSTs could be trained wildly and others may not. One fundamental factor that practitioners have to deal with is the anthropometry [62, 63]. The current study has also confirmed the anthropometrical influence on SSTs' development. It has been known that the large and widespread anthropometrical diversity limits a universal approach in motor learning and training; in many cases, an individualized approach would significantly improve the learning/training process [69, 70]. The same circumstance is also seen in the SSTs development. The selection of the players in this study happened to be two differently anthropometrical groups: short and tall. While the current study has revealed some generally practical SSTs regardless of the anthropometrical differences, it has also unveiled some anthropometrically-dependent SSTs. More future studies are needed to add more details to the general SST training and individualized SST development.

Practicality vs. effectiveness

It would be interesting to notify that the practicality would not always go along with the effectiveness. Previous studies have shown that effective shots are under one possession and zero-possession has the highest effectiveness [6, 71], which are also confirmed by the current study. Yet, part of the zero-possession shots are air-attacks. It is not surprising that Ibrahimović and Ronaldo have much higher percentage of air-attack goals. Shorter players may not gain as many as air-attach chances as taller player. Instead, from nature, short players are easier to change movement state or direction (i.e. agility) than taller player. As a compensation, shorter players could develop their dribbling ability for attacks with low effectiveness. For example, Messi's peerless dribbling ability often enable him to maliciously trespass the defenses and opening spaces for shots, even a tiny window of brief instant is enough for Messi to score a goal. Therefore, future training and practice regimes should focus not only on practicality and effectiveness of SSTs, but also on anthropometrically-dependent individualization.

CONCLUSION

This pilot study applied first time the scientific quantification in finding the practical SSTs used for scoring goals. By using career goals of 4 top elite scorers, the pilot study has revealed: 1) the practicality is increased if a SST can be applied in shots under all-body-orientation regardless of the spatial position of the ball at the instant of shooting, 2) the practicality is also associated with the SSTs that can provide either sudden change of ball motion direction at the instant of shooting or unpredictable ball flight, 3) the effectiveness is linked to shots taken with no or one setting of the ball, and 4) the practicality and effectiveness do not always go along with each other and anthropometrically-dependent characteristics should be considered in SST development. These preliminary results would supply a foundation as well as rich food for speculative thoughts for further explorations in SST development.

LIMITATION, IMPLICATIONS AND CHALLENGES

The seeming limitation of the current study is that the study is essentially a case study. Nevertheless, due to the level, quality and outstanding achievements of the selected subjects, the study has the strength to add rich and holistic implications on how-to-develop SSTs scientifically. Like case studies anchored in real-life situations, the current study has applied the simple and descriptive statistics to show aspects of practical and potential importance [72] in understanding the diversity of SSTs. These insights/ implications could be used to construe tentative hypotheses that help structure future researches and, with great potentials, advance the field's knowledge. As such the results should present the future directions in which SST research and the development of SSTs' training system should follow.

Since scientific studies on the 43 SSTs fall far behind the practice, the current research and understanding are still limited to shots taken: 1) facing the goal, and 2) with the ball between the player and the goal [2, 6]. Therefore, the inferences that can be drawn from the current study pose several challenges for projecting the potential areas of future investigations. One main challenge is how to explore the all-body-orientation shots, especially the side-facing and back-facing shots. Take the rare back-facing SSTs as examples, elite players have invented several techniques, such as bicycle kick, heel kick, jumping heel rebound, jumping turning kick and more [1], yet these SSTs are hardly studied. Another main challenge involves how to investigate the side-ball and beyond-ball shots. The current study has even proved that the side volley (i.e. a side-ball shooting technique) belongs to top practical SSTs of top elite scorers. Even more, several other side-ball and beyond-ball shooting techniques such as jumping side volley (side-ball), scorpion kick (side-ball), bicycle kick (beyond-ball) and dividing scorpion kick (beyond-ball) have been nominated by FIFA experts committee for the prestigious FIFA Puskás Award [1, 2]. Unfortunately, the side-ball and beyond-ball shooting techniques have been neglected by researchers so far [2], hence there is no systematically training system available for learning/training these SSTs. The last main challenge is how to provide scientifically-detailed advice on training of air-attack SSTs. Among the 43 SSTs identified in elite soccer games, over 60% of them can be used for air-attacks [1]. The current study has also revealed that 4 top ranked SSTs (i.e. pass kick, chip/lob kick, side volley and jumping turning header) can be applied for air-attacks. Regrettably, air-attack SSTs are understudied too.

Certainly, more structured practice of SSTs can enhance players' general scoring ability. Neglecting the scientific trainings on air-attack SSTs as well as shots taken under side-facing and back-facing postures on side-ball and beyond-ball scenarios will abnegate a significant percentage of the scoring opportunities. Unfortunately, both scientific studies and coaching practice are doing so. It is timely relevant to launch scientific innovative researches to improve the SSTs training systems.

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