



**HAL**  
open science

## **Contextual cues and stance decision-making in tennis forehand professional tennis players**

Céline Triolet, Lucile Delabarre, Nicolas Vignais, Caroline Teulier

### ► **To cite this version:**

Céline Triolet, Lucile Delabarre, Nicolas Vignais, Caroline Teulier. Contextual cues and stance decision-making in tennis forehand professional tennis players. *International journal of Sports Science and Coaching*, 2025, <10.1177/17479541251388815>. <hal-05333648>

**HAL Id: hal-05333648**

**<https://hal.science/hal-05333648v1>**

Submitted on 13 Mar 2026

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-NC 4.0 - Attribution - Non-commercial use - International License

# International Journal of Sports Science & Coaching

## CONTEXTUAL CUES AND STANCE DECISION-MAKING IN TENNIS FOREHAND PROFESSIONAL TENNIS PLAYERS

Journal:	<i>International Journal of Sports Science &amp; Coaching</i>
Manuscript ID	SPO-25-0547.R2
Manuscript Type:	Original Research Article
Date Submitted by the Author:	19-Sep-2025
Complete List of Authors:	Triolet, Céline; Université Paris-Saclay, CIAMS; Université d'Orléans, CIAMS Delabarre, Lucile; Université Paris-Saclay, CIAMS; Université d'Orléans, CIAMS Vignais, Nicolas; Université Rennes 2 Unité de Formation et de Recherche en Sciences et Techniques des Activités Physiques et Sportives, M2S INRIA Teulier, Caroline; Université Paris-Saclay, CIAMS; Université d'Orléans, Ciams
Keywords:	tennis, decision making, visual perception, expertise, training
Abstract:	In tennis, both open and square stances are used to produce forehands, although few differences have been found between them in terms of biomechanical or ball speed advantages. Hence, it is currently unclear why expert players decide to change their stance during rallies. The objective of this study was to analyze the influence of the context before the stroke on the players' stance choice. Based on video analysis of men and women professional tennis matches, 2479 stances chosen by twenty players were recorded, considering contextual factors such as "balance of power" and direction of the ball to be played. Results revealed that open stance was used significantly more than square stance in 83.6% of the forehands, with no difference between women and men. These rates varied based on the balance of power, with fewer open stance during favorable situations (65.4%). The direction of the ball played influenced the choice of stance in favorable situations, with fewer open stance being used to play cross court. Taken all together, these results showed an interaction between factors preceding the forehand stroke when adopting a stance in tennis. When players had little time to make a choice, they overwhelmingly used open stances. This choice can be automated, which reduces the attentional load. On the other hand, when they had more time, they varied their type of stance according to the zone being played, with inter-individual differences. The findings could provide valuable insights for coaches to optimize training and improve players' decision-making efficiency.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



# CONTEXTUAL CUES AND STANCE DECISION-MAKING IN TENNIS FOREHAND PROFESSIONAL TENNIS PLAYERS

Céline Triolet<sup>ab\*</sup>, Lucile Delabarre<sup>ab</sup>, Nicolas Vignais<sup>c</sup>, Caroline Teulier<sup>ab</sup>

a - Université Paris-Saclay CIAMS, 91405, Orsay, France

b - Université d'Orléans, CIAMS, 45067, Orléans, France

c - Université Rennes, M2S, INRIA, 35000, Rennes, France

\* Corresponding author.

Céline TRIOLET

Email address : [celine.triolet@universite-paris-saclay.fr](mailto:celine.triolet@universite-paris-saclay.fr)

Full postal address : Faculté des sciences du sport, Université Paris-Saclay, Rue Pierre de Coubertin,  
Bâtiment 335, 91405 Orsay Cedex, FRANCE.

## ACKNOWLEDGMENTS

All authors contributed to conception and design of the study. Céline Triolet and Lucile Delabarre organized the database. Caroline Teulier, Lucile Delabarre and Céline Triolet performed the statistical analysis. Lucile Delabarre and Céline Triolet wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

# CONTEXTUAL CUES AND STANCE DECISION-MAKING IN TENNIS FOREHAND PROFESSIONAL TENNIS PLAYERS

Revised version, September 19, 2025

Céline Triolet<sup>ab\*</sup>, Lucile Delabarre<sup>ab</sup>, Nicolas Vignais<sup>c</sup>, Caroline Teulier<sup>ab</sup>

a - Université Paris-Saclay CIAMS, 91405, Orsay, France

b - Université d'Orléans, CIAMS, 45067, Orléans, France

c - Université Rennes, M2S, INRIA, 35000, Rennes, France

\* Corresponding author.

## ABSTRACT

In tennis, both open and square stances are used to produce forehands, although few differences have been found between them in terms of biomechanical or ball speed advantages. Hence, it is currently unclear why expert players decide to change their stance during rallies. The objective of this study was to analyze the influence of the context before the stroke on the players' stance choice. Based on video analysis of men and women professional tennis matches, 2479 stances chosen by twenty players were recorded, considering contextual factors such as "balance of power" and direction of the ball to be played. Results revealed that open stance was used significantly more than square stance in 83.6% of the forehands, with no difference between women and men. These rates varied based on the balance of power, with fewer open stance during favorable situations (65.4%). The direction of the ball played influenced the choice of stance in favorable situations, with fewer open stance being used to play cross court. Taken all together, these results showed an interaction between factors preceding the forehand stroke when adopting a stance in tennis. When players had little time to make a choice, they overwhelmingly used open stances. This choice can be automated, which reduces the attentional load. On the other hand, when they had more time, they varied their type of stance according to the zone being played, with inter-individual differences. The findings could provide valuable insights for coaches to optimize training and improve players' decision-making efficiency.

**KEYWORDS:** Tennis, Decision making, Visual perception, Expertise, Training

## INTRODUCTION

Performance in sports results from the interaction of numerous factors, including anthropometric, physiological, biomechanical, technical, tactical, perceptual, and psychological characteristics [1-2-3]. In fast-paced sports like tennis, perceptual-cognitive skills such as anticipation and decision-making are critical determinants of performance [4]. Players must make rapid and accurate decisions in complex, dynamically changing environments. To simplify this process, players often associate specific situations with corresponding motor responses, thereby reducing information processing time. Marteniuk [5] defined perceptual-cognitive expertise as the ability to identify and process environmental information and integrate it with existing knowledge to facilitate response selection.

In modern tennis, despite efforts to minimize decision-making processes to save time, players still face numerous decisions before hitting the ball. For instance, after deciding between a forehand or a backhand, they must determine the trajectory of the ball (direction, length, height, speed, and spin) and select the appropriate stance: open, square, or closed [6]. The quality of the stance significantly impacts performance, as it influences stability, force generation, racket velocity, and ball accuracy [7-8]. Stances are primarily distinguished by foot positioning. Some researchers have defined these positions based on permanent fixtures (e.g., net or court lines) [6-9], while others use the hitting direction as a reference [10]. This latter aspect appears more systemic, thus describing stance as “open” when the feet are nearly perpendicular to the hitting direction, “square” when the feet are parallel, and “closed” when the feet cross the hitting direction [10]. While open stance and square stance dominate during matches, closed stance is used sparingly, mainly during backhand strokes.

From a biomechanical perspective, open stance and square stance produce distinct lower and upper limb kinematics [11-12-13], although no significant differences in ball or racket speed

1  
2  
3 have been observed [9-10]. In high-level tennis, players alternate between square stance and  
4 open stance at various moments during a match. Considering that this additional decision-  
5 making process may require information processing time, one might question why players vary  
6 their stances instead of consistently using a single type of stance.  
7  
8  
9

10  
11  
12  
13 It can be hypothesized that, to minimize information processing time, expert tennis players have  
14 developed associations between specific visual cues and the corresponding optimal stance. For  
15 example, executing a forehand with a square stance requires an additional step, with the left  
16 foot (for right-handed players) moving in front of the right foot before striking the ball,  
17 compared to the use of an open stance. Therefore, the open stance may be the preferred choice  
18 when players perceive themselves as being under time pressure. Conversely, players may opt  
19 for a square stance when they have more time to execute the stroke. When a player has gained  
20 an advantage over their opponent and has time to act, this can be defined as a favorable situation  
21 [14], in contrast to unfavorable situations, where players are under time pressure or in a  
22 defensive position. Finally, when players are constructing the point, they are in a neutral  
23 situation. Triolet et al. [14] defined these three game situations as the balance of power between  
24 two players and the time available to organize their response. This choice of balance of power  
25 is interesting as it groups in one variable the different factors of the incoming ball trajectory.  
26 For example, a deep and fast ball with a lot of spin will generate an unfavorable situation for  
27 the player.  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48

49 Once the balance of power has been assessed, players decide on the stroke parameters (e.g.,  
50 direction, length, and spin). Stroke direction, another critical factor, may influence stance  
51 selection. Studies have shown that players tend to use open stance for cross-court strokes and  
52 square stance for down-the-line strokes in controlled conditions (e.g., ball machine scenarios),  
53 outside of a match context [15]. However, during matches, stroke direction is often guided by  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 the balance of power. For example, in defensive scenarios, players frequently opt for safer  
4 strokes, particularly when positioned off-center, increasing the likelihood of cross-court play  
5 [16]. In contrast, in offensive scenarios, players have the flexibility to choose between cross-  
6 court and down-the-line strokes. Consequently, it appears that the balance of power would have  
7 a greater influence on stance selection, with stroke direction playing a secondary role, primarily  
8 in offensive situations.  
9

10  
11 To optimize tennis performance, players and coaches must better understand how contextual  
12 information influences stance selection. Ericsson and Smith's "expert performance approach"  
13 [17] emphasizes analyzing in-situ competence among elite players as a foundational step. Given  
14 that the forehand is the most frequently used stroke in tennis [6], this study aimed to investigate  
15 stance selection by elite male and female players during forehand strokes in competition. Using  
16 video analysis, we tracked two key contextual factors: the balance of power and the ball  
17 direction. The primary goal was to determine whether a priority hierarchy exists in processing  
18 contextual information that guides stance selection. If those decisions are effectively context-  
19 dependent rather than reliant on players' physical attributes, we hypothesized that there should  
20 be no gender-based significant differences.  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43

## 44 **MATERIALS AND METHODS**

### 45 **PLAYERS**

46  
47 Ten female and ten male players ( $29.55 \text{ years} \pm 5.70$ ) were observed in this analysis. They all  
48 had been in the top 13 world ranking (Women Tennis Association ranking (WTA) for women  
49 and Association of Tennis Professionals ranking (ATP) for men) for the last four years (highest  
50 ranking:  $2.05 \pm 1.64$ ). Eighteen players were right-handed and two were left-handed.  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## MATCHES and PROCEDURES

The study was based on the analysis of video footage of matches played between 2017 and 2022 during major ATP and WTA tournaments. All matches were played on hard courts with a total of forty matches analyzed against thirty-one different opponents ranked among the top 50 according to the ATP and WTA rankings. Only video footages available on the Internet and filmed from a front-on perspective were analyzed frame-by-frame using VLC media player 3.0.12 software. The data was recorded by hand on another computer on an Excel Form.

Only forehand shots that allowed the rally to continue or led to winning the point (i.e., balls that bounced within the opponent's court) were included in the analysis. Each player performed 124 forehands ( $\pm 24.88$ ) on average, against at least two different opponents, to reduce the potential bias of playing against a single opponent. For each situation, the balance of power, the direction of the ball, and the stance used were reported. The balance of power between two players included favorable, unfavorable, or neutral situations [14]. These situations were defined according to the relative position of the two players on the court when facing the opponent's stroke. More precisely, they defined a favorable situation when the player was very close to the baseline or inside the court, and when her/his opponent was in a difficult situation, playing the ball far behind the baseline (approximately more than 3 m) or away from the vertical mid-line on the court (approximately 4 m). A favorable position included situations when the opponent had to play the ball very close to the second bounce of the ball (at or below the level of the knees). An unfavorable situation corresponded to a response given to a stroke played by the opponent when he was positioned at least 2 m inside the court with a ball played at least at the height of the hips, or situations in which the observed player was not able to return to the center of his court ahead of the opponent's stroke. A neutral situation corresponded to a response during a rally when both players were on or behind the baseline in situations different from the ones described above.

1  
2  
3 The direction of the ball played could be either cross-court, when the ball bounced diagonally  
4 in the other half of the court, or down the line when the forehand was hit straight ahead in the  
5 other half of the court. Inside-out forehands and service returns were not analyzed.  
6  
7  
8  
9

10 Concerning stance analysis, this study used the hitting direction as a point of reference, as it  
11 considers the decision of the players regarding the direction of the ball [10]. Stance is said to be  
12 open when the players' feet are almost perpendicular to the hitting direction, while in square  
13 stance, the players' feet are parallel to the hitting direction (Figure 1).  
14  
15  
16  
17  
18  
19

20 **XX Figure 1 Here XX**  
21  
22  
23  
24  
25

## 26 RELIABILITY

27  
28  
29 The data coding was undertaken by one observer with 10 years of experience as a tennis player  
30 (national level). To confirm the reliability of the observation, the coding of 150 strokes was  
31 undertaken by a second independent observer, an expert tennis coach (French Tennis Federation  
32 qualification with more than 20 years of experience in coaching). A strong inter-observer  
33 agreement (Cohen's kappa coefficient [18]) was obtained for each variable, lying between 0.77  
34 and 0.92 [19]. Subsequently, a new phase of coding on these same strokes was conducted by  
35 the main observer to ensure intra-observer reliability. The observation reliability was excellent  
36 with values between 0.91 and 0.93, making those observations highly reliable [19].  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50

## 51 STATISTICAL ANALYSES

52  
53  
54 JASP Software was used to run statistical analyses. We began by running a Chi2 on the number  
55 of open and square stances used. Then, as open stance is supposedly more representative in the  
56 current game, percentages of forehand played in open stance were calculated for each player  
57  
58  
59  
60

1  
2  
3 regarding the balance of power variable (favorable/neutral/unfavorable) and the direction  
4 variable (cross-court/down the line). Then normality tests were run (Shapiro-Wilk) on every  
5 variable before running t-test and ANOVAs, as well as a homogeneity test (Levene's) for the  
6 ANOVA. An independent T-test was run on the impact of Sex (Women vs Men) on the use of  
7 open stance. Hence, we further ran a **mixed design** ANOVA with Sex (2) as a between-  
8 participants factor and Balance of power (2) and Direction (2) as within-participants factors.  
9 Effect sizes were reported for each ANOVA ( $\eta^2$ ).  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22

## 23 **RESULTS**

### 24 **STANCE and SEX**

25  
26 First, the result of the Chi2 showed a significant Stance effect ( $\chi^2=43,56$ ,  $p=.00$ ; open stances =  
27 2045; square stances = 434) (Table 1).  
28  
29  
30  
31

32 **XXX Table 1 Here XXX**

33  
34 Then, the result of an independent T-test on the use of open stance according to sex showed no  
35 Sex effect ( $t(18)=0.433$ ,  $p=.670$ ;  $d=.193$ ) (Figure 2). Indeed, men and women used mainly open  
36 stance when playing a forehand (83.62% of the time).  
37  
38  
39  
40

41 **XX Figure 2 Here XX**

### 42 **STANCE and CONTEXTUAL FACTORS**

43  
44  
45 Therefore, we focused on the results based on the percentage of open stance used when hitting  
46 a forehand, depending on the balance of power and the direction of the ball played (Figure 3).  
47  
48 A ceiling effect was observed, with little to no variability in unfavorable conditions. This  
49 suggested that players consistently made the same choice in these situations, opting for an open  
50 stance. Consequently, we excluded unfavorable situations from further statistical analysis.  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**XX Figure 3 Here XX**

ANOVA on open stance revealed no Sex effect ( $F(1,18)=.855$ ,  $p=.367$ ,  $\eta^2=.014$ ), but separate main effects for Direction ( $F(1,18)=5.609$ ,  $p=.029$ ,  $\eta^2=.023$ ), Balance of power ( $F(1,18)=54.082$ ,  $p<.001$ ,  $\eta^2=.354$ ), as well as an interaction between Direction and Balance of power ( $F(1,18)=8.528$ ,  $p=.009$ ,  $\eta^2=.31$ ). Holm post hoc tests revealed a significant difference between down-the-line shots in favorable and neutral conditions ( $t=4.131$ ;  $p<.001$ ), as well as between cross-court shots in favorable and neutral conditions ( $t=7.635$ ;  $p<.001$ ). Additionally, post hoc tests indicated a significant difference between cross-court and down-the-line shots in favorable conditions ( $t=3.727$ ;  $p=.001$ ). A decrease in the use of the open stance was observed in the favorable condition, regardless of the shot direction. This reduction was even more pronounced when players chose to hit cross-court rather than down-the-line.

**INTER-INDIVIDUAL DIFFERENCES**

When looking more into this favorable situation, a high variability in the use of open stance between players has been observed when playing cross-court ( $58.4\% \pm 21$ ) and down-the-line ( $70.4\% \pm 15$ ) (Figure 4).

**XX Figure 4 Here XX**

Based on the graphic, the twenty players could be classified into four distinct groups (Figure 4). In the first group, eight players used open stance to play cross-court ( $77.8\% \pm 10.2$ ) in a similar manner to when playing down-the-line ( $74.9\% \pm 13.5$ ). The second group of six players would also use open stance to play cross-court but less often than the first group ( $60\% \pm 6.6$ ) and less so when hitting down-the-line ( $75.4\% \pm 6.8$ ). The third group of four players barely

1  
2  
3 used open stance to play cross-court ( $29.1\% \pm 4.7$ ); however, in a similar manner to the other  
4  
5 players, they adopted open stance when hitting down-the-line ( $70\% \pm 5.3$ ). Finally, the two  
6  
7 remaining players used open stance less than square stance, regardless of the direction of their  
8  
9 cross-court ( $34.8\% \pm 2.1$ ) or down-the-line strokes ( $37.7\% \pm 6.2$ ).  
10  
11  
12  
13

## 14 DISCUSSION

15  
16  
17 By analyzing top-level tennis players, this study tried to understand which contextual  
18  
19 information came into play when selecting stance in tennis forehand.  
20

21  
22 First, our results showed that contextual information (i.e., balance of power and direction of the  
23  
24 ball) are key components in choosing stances, which are mainly opened to play forehand  
25  
26 ( $83,62\%$ ) in our study or in modern tennis ( $67\%$  to  $90\%$  of open stance reported [6-20-21]).  
27

28  
29 Indeed, we showed that tennis players used open stance almost  $100\%$  of the time when under  
30  
31 pressure in unfavorable situations. Even in neutral situations, picking this contextual  
32  
33 information allows for determining more than  $90\%$  of the choices made by players. Hence, our  
34  
35 results clearly demonstrated that time pressure is a key factor in choosing an open stance, as  
36  
37 Landlinger et al. suggested [15]. Beside the fact that open stance in defensive situations seems  
38  
39 to carry a higher risk of knee injuries [22], the evolution of tennis towards a more explosive and  
40  
41 faster game may explain why the open stance is prioritized when time is lacking, as this stance  
42  
43 requires one less step than the square stance, either in the women's or men's game. Hence, in  
44  
45 defensive situations, the time pressure seemed to be the only factor determining stance choices,  
46  
47 while the direction of the ball was not even taken into account. Removing the choice of stance  
48  
49 in these situations means that high-level players associate a specific response (open stance) with  
50  
51 a specific situation, thereby eliminating the first step of the stimulus-response association in  
52  
53 information processing. By doing so, players reduce the time needed to plan their movements,  
54  
55 allowing them to react faster on the court during defensive or unfavorable situations [23-24].  
56  
57  
58  
59  
60

1  
2  
3 On the contrary, when players have more time to play (i.e., in favorable situations), they  
4 **broaden their options** to either an open stance or a square stance. Even **though** varying stances  
5  
6 in this situation increase their reaction time, being under less time pressure allows for such  
7  
8 **flexibility**. Although players use the open stance more often when playing down the line (70%  
9  
10  $\pm$  15) in favorable situations, other contextual information has been **considered in their decision-**  
11  
12 **making**, which could explain the variance observed. It would be interesting to track extra  
13  
14 contextual **factors** in this specific situation **such as** where the ball comes from, where it is played  
15  
16 from, or **whether** the player is approaching the net), to determine **whether** each player has a  
17  
18 specific association between context and stance in favorable situations.  
19  
20  
21  
22

23  
24 This is even more obvious when looking at favorable situations where players go for a cross-  
25  
26 court forehand, with only 58% ( $\pm$  21) of open stances used. Here, we showed that the direction  
27  
28 of the ball came into play, but the interaction between the two factors, i.e., balance of power  
29  
30 and direction, is not sufficient to explain the choices made by the players. By analyzing players  
31  
32 more individually, it seems that some players tend to use open stance **more often regardless** of  
33  
34 the direction of the ball in favorable/offensive situations, while others favor square stance. In  
35  
36 between, some players give priority to square stance only when playing cross-court. These  
37  
38 differences, besides the contextual information, might come from individual factors **such as** the  
39  
40 laterality profiles of the players [25-26]. This raises the question of why those players make a  
41  
42 physical effort to take an extra step needed for square stance. It may be related to their intrinsic  
43  
44 characteristics (anthropometric, physiological, or their natural preferences [27]), or to a greater  
45  
46 benefit in terms of performance (speed, accuracy) that this type of stance may provide in this  
47  
48 condition of play. Indeed, so far, the literature has only pooled all the balance of power  
49  
50 situations together while looking at the impact of stance on ball speed, hence showing no effect  
51  
52 on it [13]. More ecological studies **placing** players in specific situations (i.e.,  
53  
54 favorable/unfavorable) would be needed to better understand these differences.  
55  
56  
57  
58  
59  
60

1  
2  
3 It can also be noticed that this result is in contradiction with previous work in which square  
4 stance was supposedly the most used to play down the line in favorable situations [15]. This  
5 difference could be related to the definition of stance: stances were defined based on permanent  
6 fixtures like the net, rather than the hitting direction, as in the current study. Moreover, this  
7 latter study was not conducted in real game conditions [15], which might not have created the  
8 ecological situation in which square stance might be adopted by players.  
9

10  
11  
12 Secondly, even if women athletes are known to be less powerful than equally trained men [28],  
13 our results did not show differences in terms of choice of stance used. This outcome tends to  
14 confirm that this choice is linked to the context of the game and not to physical qualities.  
15

16  
17  
18 Although more in-depth studies are needed to better understand the choices made in favorable  
19 situations, current outcomes allow us to draw some conclusions and perspectives for the training  
20 of future tennis players. Indeed, modern tennis seems too fast to allow players to make any  
21 choice while under time pressure, meaning that coaches have to teach young players, with no  
22 difference between sexes, to associate open stance with unfavorable situations. This means that  
23 recognizing such situations should be trained early on, as it is a key point when optimizing a  
24 forehand, in terms of time and technique. Moreover, our study points out that professional  
25 players might see some advantages in switching to square stance in some situations. Hence,  
26 biomechanical studies that did not find advantages between these two stances might have  
27 missed an important point [9]. The fact that those studies were run in laboratory settings,  
28 without any context, might have hidden the benefits of square stance. The translation of the  
29 body, only possible when using square stance, might help the player to be more accurate while  
30 keeping a good speed, for example, when the player is inside the court. It is also highly possible  
31 in such favorable situations that the role of coaches will be to figure out what the best option is  
32 for each player, based on their individual characteristics. Defining a strong association between  
33 one situation and the response (i.e., type of stance) will also be a useful strategy to save time in  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 movement planning, hence playing faster and reducing the time for the opponent to react to the  
4  
5 situation.  
6

7  
8 Finally, one of the limits of the current study is related to the fact that stance was only analyzed  
9  
10 in a **dichotomous** manner. Players are surely using a more refined repertoire of stances, varying  
11  
12 angles between their feet, and the direction of the ball. Using a more refined scale to analyze  
13  
14 stances might help scientists to better understand their benefits **for** performance, while  
15  
16 considering the analysis of the situation leading to the players' decision to use or not use one  
17  
18 specific stance.  
19  
20  
21  
22

## 23 **CONCLUSIONS**

24  
25  
26 In neutral and unfavorable situations, players tend to favor the open stance. Coaches can  
27  
28 therefore focus on automating this stance in such conditions to reduce cognitive load.  
29

30  
31 In favorable situations, a more nuanced approach is required, as stance selection appears to  
32  
33 depend on both shot direction and individual player characteristics. Further research is needed  
34  
35 to determine which stance optimally enhances shot speed and accuracy in favorable conditions,  
36  
37 as well as to identify the different contextual cues that influence this decision-making process.  
38  
39  
40  
41  
42  
43  
44

## 45 **STATEMENTS AND DECLARATIONS**

### 46 47 48 49 **ETHICAL CONSIDERATIONS**

50  
51  
52 Not applicable.  
53  
54  
55

### 56 57 **CONSENT TO PARTICIPATE**

58  
59 Not applicable.  
60

1  
2  
3  
4  
5 CONSENT FOR PUBLICATION  
6  
7

8 Not applicable.  
9  
10  
11

12 DECLARATION OF INTEREST STATEMENT  
13

14 The authors declared no potential conflicts of interest with respect to the research, authorship,  
15 and/or publication of this article.  
16  
17  
18  
19  
20

21 FUNDING STATEMENT  
22

23 The authors received no financial support for the research, authorship, and/or publication of  
24 this article.  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**REFERENCES**

1. Newell KM. Constraints on the Development of Coordination. Dans: Wade MG, Whiting HTA. Motor Development in Children: Aspects of Coordination and Control. Dordrecht: Springer Netherlands ; 1986. p.341-60. [https://doi.org/10.1007/978-94-009-4460-2\\_19](https://doi.org/10.1007/978-94-009-4460-2_19).
2. Phomsoupha M, Laffaye G. The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. Sports Med. 2015 Apr;45(4):473-95. doi: 10.1007/s40279-014-0287-2.
3. Kovacs MS. Applied physiology of tennis performance. Br J Sports Med. 2006 May;40(5):381-5. doi: 10.1136/bjism.2005.023309.
4. Williams AM, Ford PR, Eccles DW, Ward P. Perceptual-cognitive expertise in sport and its acquisition: Implications for applied cognitive psychology. Appl Cognit Psychol 2011; 25(3): 432-42. doi: 10.1002/acp.1710.
5. Marteniuk RG. Information Processing in Motor Skills. New York, NY: Holt, Rinehart, and Winston ; 1976.
6. Reid M, Elliott B, Crespo M. Mechanics and learning practices associated with the tennis forehand: a review. J Sports Sci Med. 2013 Jun 1;12(2):225-31.
7. Martin C. Analyse biomécanique et musculaire du coup droit. Dans : Tennis optimisation de la performance. Paris, De Boeck Supérieur ; 2018.
8. Takahashi K, Elliott B, Noffal G. The role of upper limb segment rotations in the development of spin in the tennis forehand. Aust J Sci Med Sport. 1996 Dec;28(4):106-13.
9. Knudson D, Bahamonde RE. Trunk and racket kinematics at impact in the open and square stance tennis forehand. Biol Sport. 1999;16(1):3-10.

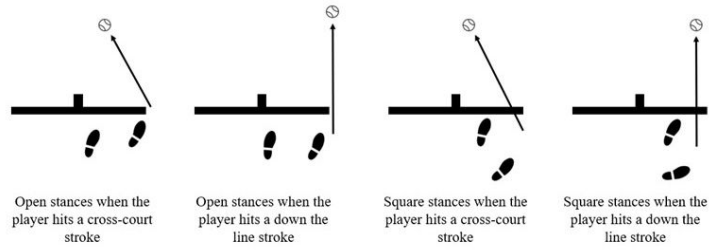
- 1  
2  
3 10. Kawamoto Y, Iino Y, Yoshioka S, Fukashiro S. Directionally compensated mechanical  
4  
5 work provided by the shoulder leads to similar racket velocities during open and square  
6  
7 stance forehand groundstrokes in tennis. *Eur J Sport Sci*. 2019 Aug;19(7):902-912. doi:  
8  
9 10.1080/17461391.2018.1552720.  
10  
11
- 12 11. Bahamonde RE, Knudson D. Kinetics of the upper extremity in the open and square  
13  
14 stance tennis forehand. *J Sci Med Sport*. 2003 Mar;6(1):88-101. doi: 10.1016/s1440-  
15  
16 2440(03)80012-9.  
17  
18
- 19 12. Knudson D, Blackwell J. Trunk muscle activation in open stance and square stance  
20  
21 tennis forehands. *Int J Sports Med*. 2000 Jul;21(5):321-4. doi: 10.1055/s-2000-3776.  
22  
23
- 24 13. Lambrich J, Muehlbauer T. Biomechanical analyses of different serve and groundstroke  
25  
26 techniques in tennis: A systematic scoping review. *PLoS One*. 2023 Aug  
27  
28 17;18(8):e0290320. doi: 10.1371/journal.pone.0290320.  
29  
30
- 31 14. Triolet C, Benguigui N, Le Runigo C, Williams AM. Quantifying the nature of  
32  
33 anticipation in professional tennis. *J Sports Sci*. 2013;31(8):820-30. doi:  
34  
35 10.1080/02640414.2012.759658.  
36  
37
- 38 15. Landlinger J, Lindinger SJ, Stöggel T, Wagner H, Müller E. Kinematic differences of  
39  
40 elite and high-performance tennis players in the cross court and down the line forehand.  
41  
42 *Sports Biomech*. 2010 Nov;9(4):280-95. doi: 10.1080/14763141.2010.535841.  
43  
44
- 45 16. Loffing F, Hagemann N. On-court position influences skilled tennis players'  
46  
47 anticipation of shot outcome. *J Sport Exerc Psychol*. 2014 ; 36:14–26. doi:  
48  
49 10.1123/jsep.2013-0082.  
50  
51
- 52 17. Ericsson KA, Smith J. Prospects and limits of the empirical study of expertise: An  
53  
54 introduction. Dans: *Toward a general theory of expertise: Prospects and limits*. New  
55  
56 York: Cambridge University Press; 1991. p.1-38.  
57  
58  
59  
60

- 1  
2  
3 18. Cohen J. A Coefficient of Agreement for Nominal Scales. Educational and  
4  
5 Psychological Measurement. 1960 ; 20(1): 37 - 46.  
6  
7
- 8 19. Landis JR, Koch GG. The measurement of observer agreement for categorical data.  
9  
10 Biometrics. 1977 ; 33(1):159-174.  
11
- 12 20. Schönborn R. Advanced techniques for competitive tennis. Aachen: Meyer and Meyer  
13  
14 Sport; 1999.  
15
- 16 21. Zusa A, Lanka J, Vagin A. Biomechanical analysis of forehand in modern tennis. LASE  
17  
18 J Sport Sci. 2010; 1(1):13-17.  
19
- 20 22. Martin C, Sorel A, Touzard P, Bideau B, Gaborit R, DeGroot H, Kulpa R. Influence of  
21  
22 the forehand stance on knee biomechanics: Implications for potential injury risks in  
23  
24 tennis players. J Sports Sci. 2021 May;39(9):992-1000. doi:  
25  
26 10.1080/02640414.2020.1853335.  
27  
28
- 29 23. Wong AL, Haith AM, Krakauer JW. Motor Planning. Neuroscientist. 2015  
30  
31 Aug;21(4):385-98. doi: 10.1177/1073858414541484.  
32  
33
- 34 24. Cano LA, Gerez GD, García MS, Albarracín AL, Farfán FD, Fernández-Jover E.  
35  
36 Decision-Making Time Analysis for Assessing Processing Speed in Athletes during  
37  
38 Motor Reaction Tasks. Sports. 2024;12(6):151. <https://doi.org/10.3390/sports1206015>.  
39  
40
- 41 25. Coren S. The lateral preference inventory for measurement of handedness, footedness,  
42  
43 eyedness, and earedness: norms for young adults. Bull. Psychon. Soc. 1993; 31, 1–3.  
44  
45
- 46 26. Castañer M, Andueza J, Hileno R, Puigarnau S, Prat Q, Camerino O. Profiles of Motor  
47  
48 Laterality in Young Athletes' Performance of Complex Movements: Merging the  
49  
50 MOTORLAT and PATHoops Tools. Front Psychol. 2018 Jun 7;9:916. doi:  
51  
52 10.3389/fpsyg.2018.00916.  
53  
54
- 55 27. Deghaies K, Martin C, Touzard P, Brechbuhl C, Duboscq JM, Lussiana T, Gindre C.  
56  
57 The effect of natural preferences on serving biomechanics: a new approach to the motor  
58  
59  
60

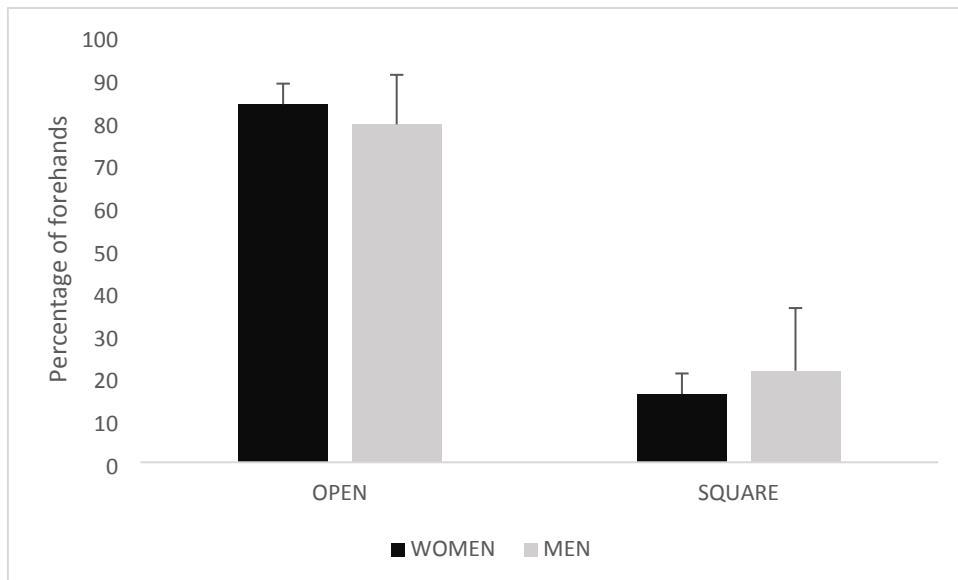
1  
2  
3 skills of tennis players. *ITF Co. & Sp. Sc. Rev.* 2021 Sep 3;29(84):15-7. doi:  
4  
5 10.52383/itfcoaching.v29i84.201.  
6

- 7  
8 28. Bartolomei S, Grillone G, Di Michele R, Cortesi M. A Comparison between Male and  
9  
10 Female Athletes in Relative Strength and Power Performances. *J Funct Morphol*  
11  
12 *Kinesiol.* 2021 Feb 9;6(1):17. doi: 10.3390/jfmk6010017.  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

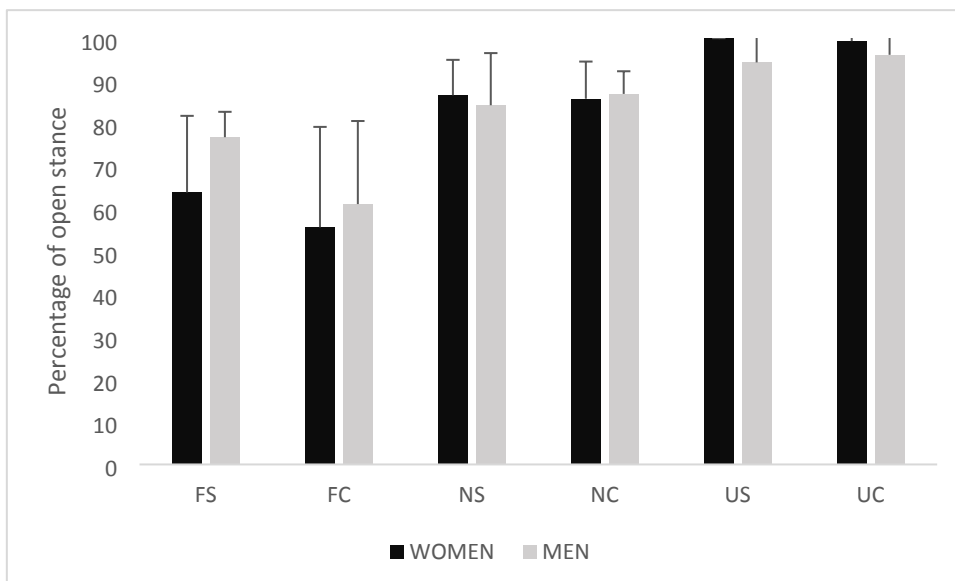
**FIGURES**



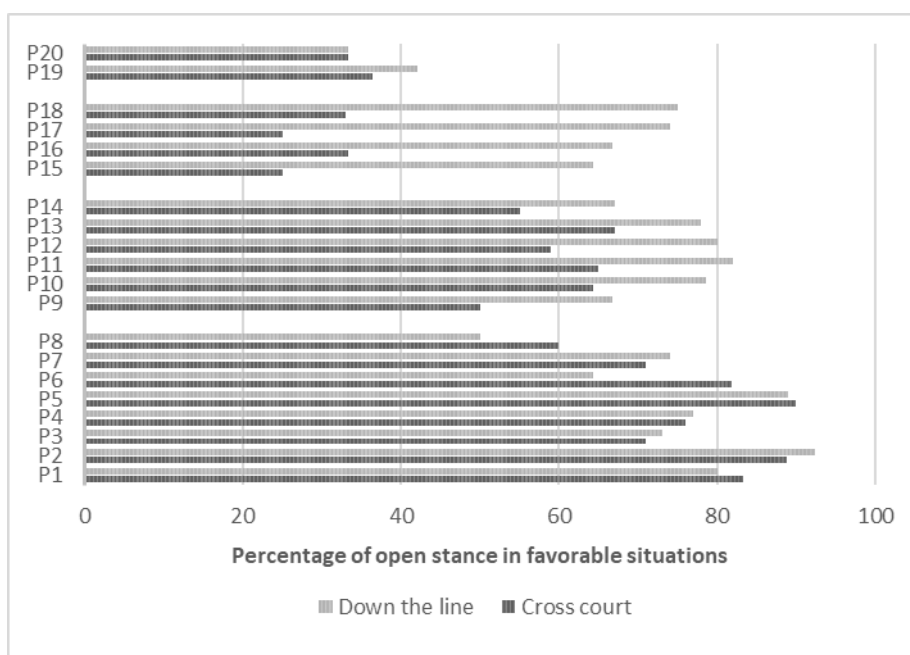
**FIGURE 1**



**FIGURE 2**



**FIGURE 3**



**FIGURE 4**

## FIGURE CAPTIONS

Figure 1. Illustration representing open stance and square stance relative to the direction of the ball played in forehand for a right-handed player based on the definition by Kawamoto et al. [10].

Figure 2. Percentages of forehands played in open stance and square stance according to the sex.

Figure 3. Percentages of open stance used according to sex, balance of power, and direction of the ball played. The balance of power is given by the first letter of the condition: Favorable (F); Neutral (N); Unfavorable (U). The second letter of the condition gives the direction of the ball: Straight (S) or Crossed (C).

Figure 4. Players regarding their percentage of open stance in favorable situations according to the cross-court and down the line directions.

**TABLE**

Table 1: Number of forehands played with open stance in each situation over the total number of forehands recorded per situation (men and women added together)

	Favorable	Neutral	Unfavorable
Straight	258 / 357	394 / 455	165 / 167
Cross	143 / 242	876 / 1015	237 / 243

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

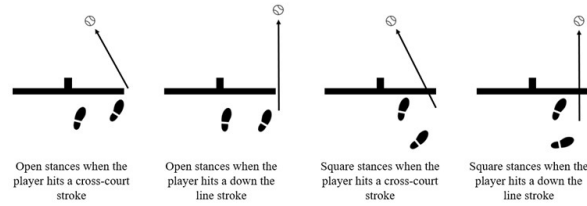


Figure 1. Illustration representing open stance and square stance relative to the direction of the ball played in forehand for a right-handed player based on the definition by Kawamoto et al. [9].

338x190mm (96 x 96 DPI)

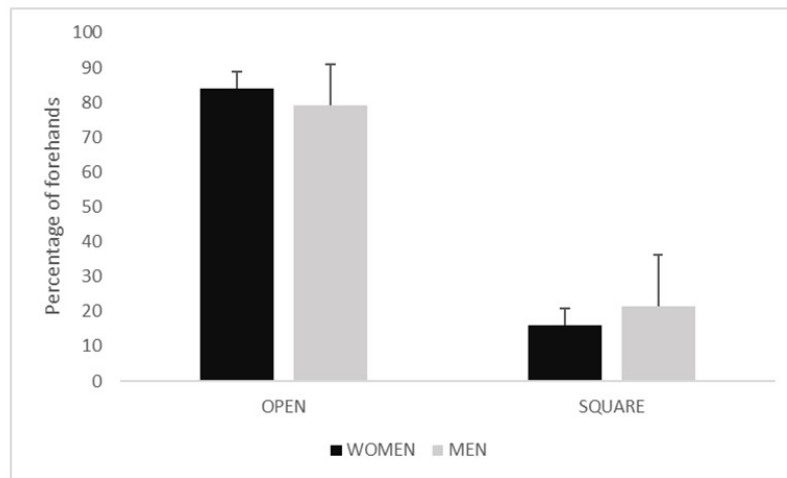


Figure 2. Percentages of forehands played in open stance and square stance according to the sex.

254x190mm (96 x 96 DPI)

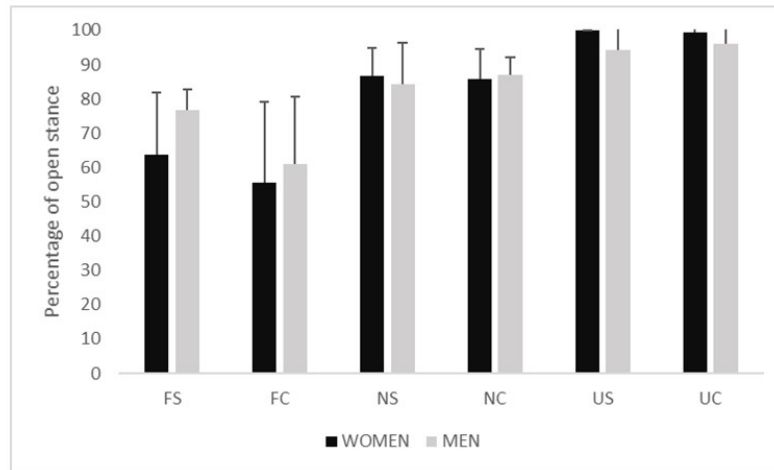


Figure 3. Percentages of open stance used according to sex, balance of power, and direction of the ball played. The balance of power is given by the first letter of the condition: Favorable (F); Neutral (N); Unfavorable (U). The second letter of the condition gives the direction of the ball: Straight (S) or Crossed (C).

254x190mm (96 x 96 DPI)

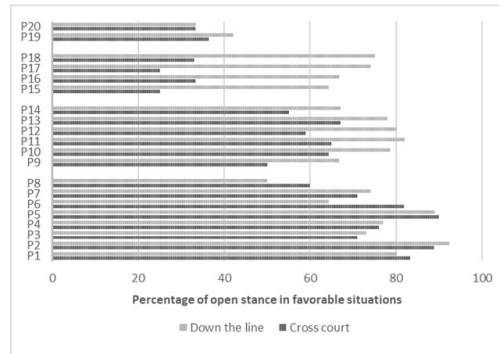


Figure 4. Players regarding their percentage of open stance in favorable situations according to the cross-court and down the line directions.

338x190mm (96 x 96 DPI)

Table 1: Number of forehands played with open stance in each situation over the total number of forehands recorded per situation (men and women added together)

	Favorable	Neutral	Unfavorable
Straight	258 / 357	394 / 455	165 / 167
Cross	143 / 242	876 / 1015	237 / 243