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SEX DIFFERENCES IN PASSING PERFORMANCE IN ELITE INTERNATIONAL FOOTBALL: A MULTIDIMENSIONAL ANALYSIS OF PASS LENGTH AND PITCH ZONE IN FIFA WORLD CUPS

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Abstract

Introduction. This study examined sex differences in passing performance using match data from the 2022 FIFA Men's World Cup and the 2023 FIFA Women's World Cup. A total of 128 team observations per tournament were analyzed using StatsBomb event data. **Material and Methods.** Passing performance was assessed using pass frequency, pass completion rate, mean pass distance, pass length categories (short, medium, and long), and pitch zones (defensive, middle, and attacking thirds). **Results.** Men showed significantly higher values for number of passes, pass completion rate, and mean pass distance than women. Women exhibited a higher proportion of short passes and a lower proportion of medium passes, whereas no clear difference was observed in long-pass proportion. Although pass distribution across pitch zones was similar between sexes, women attempted fewer passes in the defensive and middle thirds. Significant interactions between sex, pass length, and pitch zone were observed for all variables (all $p < 0.05$), indicating that sex differences depended on tactical context. **Conclusions.** These findings suggest that sex differences in football passing performance are context-dependent rather than uniform. Integrating pass length and spatial context provides a more comprehensive understanding of performance differences between men's and women's football and may inform coaching and performance analysis in elite football.

Keywords: football analytics, passing performance, sex differences, pass length, pitch zone

Introduction

Passing is a fundamental component of modern football, serving as a key mechanism for ball possession, progression, and chance creation. Passing patterns reflect team tactical behavior, and variables such as number of passes, pass completion rate, and spatial distribution have been reported to be associated with team performance and match outcomes [1, 2]. In recent years, the rapid development of large-scale databases, such as StatsBomb, FBref and Opta, has enabled detailed quantitative analyses using event and tracking data [3, 4, 5, 6, 7, 8]. These datasets provide precise information on pass origin and destination, distance, outcome, and pitch location, allowing for systematic investigation of tactical behaviors that were previously difficult to quantify.

One common approach to analyzing passing behavior is classification based on pass length. Previous studies have frequently categorized passes into short (<10 m), medium (10-30 m), and long (>30 m) distances [2, 7]. This classification is based on the premise that passes serve different tactical functions, such as ball possession, build-up play, and progression, and that sequences of passes constitute the fundamental units of team tactics [9, 10]. In general, short passes contribute to ball retention and local combinations, medium-distance passes are involved in the construction of attacking play, and long passes are used as a means of spatial expansion and forward progression. In addition, pitch-based analyses that divide the field into the defensive

(DT), middle (MT), and attacking thirds (AT) are widely used [11, 12, 13]. Passing behaviors within each zone are associated with different tactical functions, such as safe build-up in the DT, offensive organization in the MT, and chance creation in the AT [14, 15]. Therefore, integrating pass length and pitch location is essential for understanding the tactical context of passing actions.

Recent studies comparing men's and women's football have reported complex and sometimes inconsistent findings. Yang et al. [16] found no significant differences in passing network structures between men's and women's elite leagues, suggesting similarities in team organization and ball circulation. In contrast, Ju et al. [17] reported that women's football tends to involve a more direct playing style, with fewer off-ball movements and less pressing. Furthermore, Iván-Baragaño et al. [18] identified differences in technical and tactical indicators between male and female elite players using data mining approaches. These findings suggest that sex-related differences in football performance are not uniform but may depend on the specific variables and tactical contexts being analyzed.

However, most previous studies have focused on overall passing indicators or network-based metrics, without simultaneously considering pass length and pitch location. In particular, studies directly comparing men's and women's football at the same elite competition level while integrating these two dimensions remain limited. Context-dependent analyses that incorporate both spatial and tactical factors are necessary to

capture nuanced differences that cannot be identified through aggregated metrics alone. The 2022 FIFA Men's World Cup in Qatar and the 2023 FIFA Women's World Cup in Australia and New Zealand provide a unique opportunity for comparison while reflecting contemporary elite-level football performance. Comparative analysis of these tournaments offers an opportunity to examine potential sex-related differences in tactical behaviors under similar competitive conditions.

Therefore, the purpose of this study was to comprehensively compare passing characteristics between the 2022 men's and 2023 women's FIFA World Cups, focusing on number of passes, pass completion rate, pass length categories (short, medium, and long), and pitch zones (DT, MT, and AT). In particular, this study aimed to identify sex-related differences within a multi-dimensional framework that integrates pass length and spatial context.

Based on previous research, it was hypothesized that men's teams would exhibit a higher proportion of long-distance passes compared to women's teams. This assumption is grounded in findings suggesting that men's football is characterized by higher-intensity play and greater utilization of space for forward progression, as well as evidence indicating that differences in playing style may influence pass length characteristics [17, 18].

Furthermore, it was hypothesized that sex-related differences would not be uniformly observed across all passing variables, but would instead be more pronounced within specific pass length categories and pitch areas. This assumption is based on studies reporting that the presence or absence of sex differences varies depending on the performance indicators examined [16-18], as well as evidence that tactical behaviors in football are strongly influenced by spatial and situational contexts [14]. In other words, differences between men's and women's football are likely to emerge not in aggregated indicators such as overall pass volume or completion rate, but within the tactical context defined by the combination of pass length and pitch location.

The findings of this study are expected to contribute to a deeper understanding of tactical characteristics in men's and women's football and to provide practical implications for coaching and tactical decision-making.

Material and Methods

Data Source and Sample

This study analyzed all matches from the 2022 FIFA Men's World Cup (hereafter, men's World Cup) and the 2023 FIFA Women's World Cup (hereafter, women's World Cup). Each tournament consisted of 64 matches, including both group and knockout stages. For each match, both competing teams were treated as independent analytical units, resulting in 128 team observations per tournament.

Event data were obtained from the publicly available StatsBomb open-data repository (Bath, UK), which provides high-resolution football event data for research purposes [19]. The use of these data complies with the StatsBomb public data user agreement. StatsBomb data have been widely used in previous sports science research for tactical and performance analyses [20, 21, 22], and their reliability and validity have been reported in the literature [23]. StatsBomb data are collected using a multi-analyst tagging system based on video footage. Specifically, multiple analysts annotate player actions and spatial information, while additional reviewers and automated validation processes are employed to ensure high accuracy and consistency. The dataset includes detailed information for each event, such as event type, timestamp, outcome, and spatial coordinates (x, y),

recorded on a standardized pitch of 120 × 80 units. Data extraction and preprocessing were performed using Python (version 3.x) and the StatsBomb API library (statsbombpy). Additional data handling was conducted using pandas and NumPy. All pass events were extracted from each match, and the following variables were obtained: start location, end location and pass outcome. No missing values were identified in the variables required for analysis. To ensure comparability across matches, attacking direction was standardized such that each team's attacking play was aligned in the same direction. All spatial analyses were conducted based on this normalized coordinate system.

Variable Definitions

Pass distance was calculated as the Euclidean distance between the start and end coordinates of each pass. Because StatsBomb coordinates are recorded on a standardized pitch (120 × 80 units), distances were converted to meters using a standard pitch dimension of 105 m × 68 m.

Passes were categorized into three groups based on their distance: short passes (<10 m), medium passes (10-30 m), and long passes (≥30 m). This classification follows commonly adopted approaches in previous research [7].

The pitch was divided longitudinally into three equal zones: DT, MT, and AT. Each pass was assigned to a zone based on its starting location. Since the tactical context of a pass is primarily determined by its origin, classification was based on the start coordinates. All coordinates were transformed according to each team's attacking direction prior to classification.

Performance Indicators

For each team in each match, overall passing performance was quantified using total number of passes, number of completed passes, pass completion rate (completed passes divided by total passes × 100), and mean pass distance. In addition, the number of passes, and pass completion rate were calculated separately for each pass-length category and pitch zone. The mean distance of passes within each category was also calculated. Furthermore, the proportion of passes belonging to each pass-length category and pitch zone relative to the total number of passes was determined.

Exclusion Criteria

To ensure comparability across matches and focus on open-play behavior, specific events were excluded from the analysis. Matches that included extra time were restricted to the standard 90 minutes, excluding all events occurring during extra time. Additionally, the initial actions following set plays were excluded. Specifically, passes classified as Free Kick, Corner, Throw-in, Goal Kick, or Kick-off were removed when they represented the first action immediately following the restart. Subsequent passes occurring after the restart phase were retained, as they were considered part of open play.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics (version 28.0), with the significance level set at $\alpha = 0.05$. Normality and homogeneity of variance were assessed prior to analysis, and Welch's t-test was applied when necessary.

Differences between men's and women's tournaments in overall passing variables (number of passes, pass completion rate, and mean pass distance) were evaluated using independent-samples t-tests.

A two-way analysis of variance (ANOVA) was conducted with sex as a between-subject factor and pass length category as

a within-subject factor. Dependent variables included number of passes, pass completion rate, and mean pass distance within each category. Significant interactions were followed by simple main effects analyses. A two-way ANOVA was performed with sex as a between-subject factor and pitch zone as a within-subject factor. The same dependent variables were used. A three-way ANOVA was conducted with sex as a between-subject factor and both pass length category and pitch zone as within-subject factors. This analysis allowed examination of context-dependent differences in passing behavior.

To examine sex differences in the distribution of pass characteristics while accounting for the compositional nature of the data (i.e., proportions summing to 100%), multivariate analyses of variance (MANOVA) were conducted. First, MANOVA was performed to assess differences in pass-length distribution (short, medium, and long passes) between men's and women's tournaments. Second, MANOVA was conducted to examine differences in pass distribution across pitch zones (defensive, middle, and attacking thirds). Third, to investigate context-dependent differences, a multivariate analysis was performed on the combined distribution of pass length and pitch zone (i.e., the proportion of passes within each pass length $\times$ pitch zone combination).

Sphericity was assessed using Mauchly's test, and Greenhouse-Geisser corrections were applied when necessary. When significant effects were observed, post hoc comparisons were conducted with Bonferroni correction. Effect sizes were reported as partial eta squared (η^2), interpreted as small (0.01), medium (0.06), and large (0.14) [24, 25].

Ethical Considerations

This study was based exclusively on publicly available, anonymized secondary data obtained from the StatsBomb Open Data repository. No human participants were recruited or directly involved in the study, no personal or identifiable data were collected, and therefore, according to institutional and international ethical guidelines, ethical committee approval and informed consent were not required.

Results

Men showed a significantly higher number of passes, pass completion rate, and mean pass distance than women (all $p < 0.01$) (Tab. 1).

A significant multivariate effect of sex on pass length distribution was observed (Wilks' $\Lambda = 0.92$, $F(2, 253) = 11.46$, $p < 0.001$, $\eta^2 = 0.08$), indicating that the proportion of passes differed between men and women across pass length categories. Specifically, women showed a lower proportion of medium passes and a relatively higher proportion of short passes compared to men, whereas no clear difference was observed in long passes (short: $19.4 \pm 3.7\%$ vs. $22.1 \pm 2.3\%$; medium: $62.9 \pm 5.1\%$ vs. $59.8 \pm 6.6\%$; long: $17.7 \pm 3.9\%$ vs. $18.1 \pm 3.9\%$) (Fig. 1A).

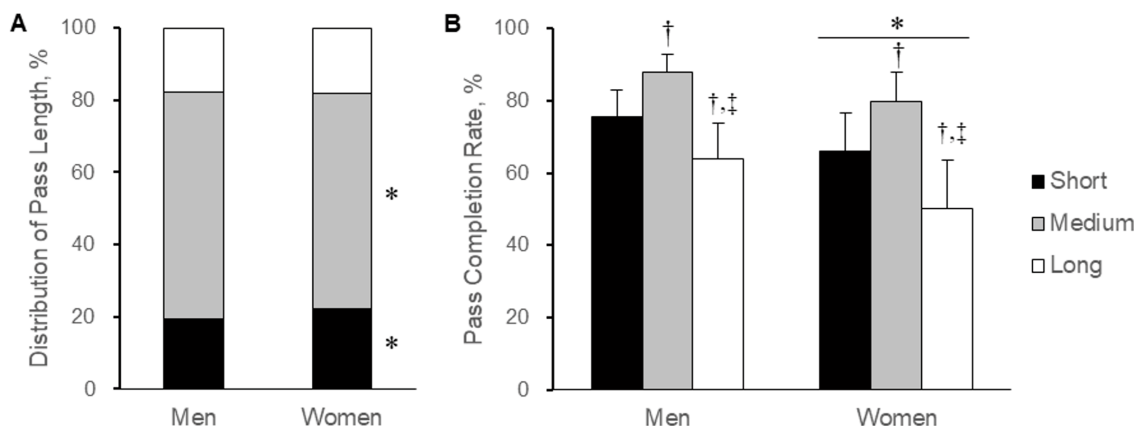
A significant interaction between sex and pass length was observed for all variables (all $p < 0.001$) (Tab. 2), indicating that sex differences in passing performance varied across pass length categories. Given this interaction, simple effects were examined. Women performed fewer medium and long passes than men, whereas the difference in short passes was relatively small. Similarly, pass completion rate was lower in women across all pass length categories (Tab. 2, Fig. 1B). These findings indicate that sex differences were present across pass length categories.

No significant multivariate effect of sex on pass distribution across pitch zones was observed (Wilks' $\Lambda = 0.99$, $F(2, 253) = 1.24$, $p = 0.29$, $\eta^2 = 0.01$), indicating that the distribution of passes across pitch zones was similar between men and women (Fig. 2A).

Table 1. Comparison of overall passing performance between men's and women's FIFA World Cups

Variables	Men (95%CI)	Women (95%CI)	p-value of t-test (Cohen's d)
Number of passes, n	471.5 $\pm$ 151.5 (444.9-498.0)	400.2 $\pm$ 152.1 (373.6-426.8)	< 0.001 (0.47)
Completion rate, %	81.3 $\pm$ 6.0 (80.2-82.3)	71.6 $\pm$ 9.5 (69.9-73.2)	< 0.001 (1.22)
Distance, m	20.5 $\pm$ 1.4 (20.2-20.7)	19.9 $\pm$ 1.4 (19.7-20.2)	< 0.01 (0.40)

Values are presented as mean $\pm$ standard deviation (95% confidence interval). Differences between men and women were assessed using independent-samples t-tests. Effect sizes are reported as Cohen's d.



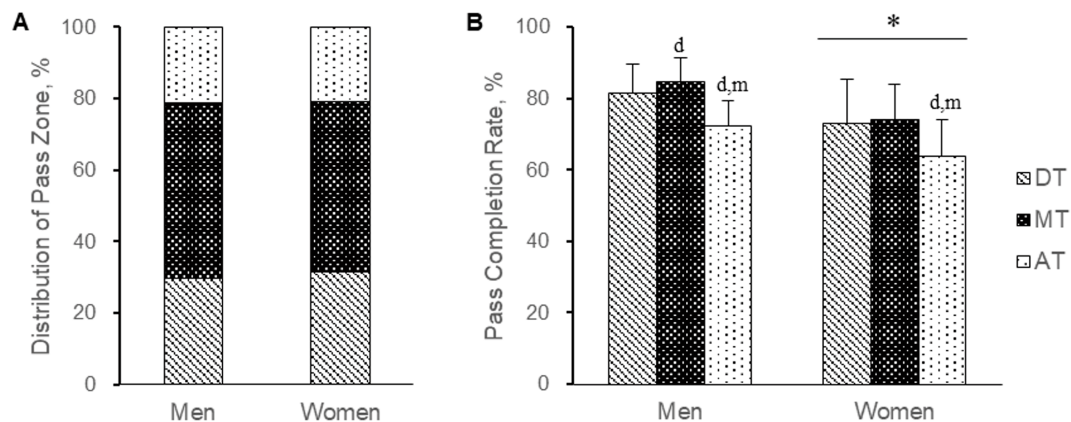
(A) Distribution of passes across pass length categories (short, medium, and long) for men and women. Values are expressed as percentages of total passes. (B) Pass completion rate (%) for each pass length category in men and women. Data are presented as mean $\pm$ standard deviation. * – significant difference between men and women within the same pass length category ($p < 0.05$). †, ‡ – Significant difference compared with short and medium passes within the same sex, respectively ($p < 0.05$).

Fig. 1. Sex differences in pass length distribution and pass completion rate.

Table 2. Sex differences in passing performance across pass length categories.

Variables	Pass Length			p-value of 2-way ANOVA (partial η^2)		
				Interaction (Sex × Pass Length)	Main effect	
	Short (95%CI)	Medium (95%CI)	Long (95%CI)		Sex	Pass Length
Number of passes, n						
Men	90.0 ± 29.3 (84.8-95.1)	301.5 ± 116.5† (281.1-321.9)	80.0 ± 19.7†‡ (76.6-83.5)	< 0.001 (0.05)	< 0.001 (0.05)	< 0.001 (0.79)
Women	84.5 ± 28.2 (79.6-89.5)	246.5 ± 113.7*† (226.6-266.4)	69.2 ± 22.0*†‡ (65.4-73.1)			
Completion rate, %						
Men	75.5 ± 7.3 (74.2-76.8)	88.0 ± 4.9† (87.1-88.8)	64.0 ± 9.7†‡ (62.3-65.7)	< 0.001 (0.05)	< 0.001 (0.31)	< 0.001 (0.82)
Women	66.0 ± 10.7* (64.2-67.9)	79.8 ± 8.1*† (78.4-81.2)	50.1 ± 13.4*†‡ (47.8-52.4)			
Distance, m						
Men	6.9 ± 0.4 (6.9-7.0)	18.1 ± 0.5† (18.0-18.2)	43.4 ± 2.4†‡ (42.9-43.8)	< 0.001 (0.06)	< 0.001 (0.12)	< 0.001 (0.99)
Women	6.7 ± 0.4* (6.6-6.7)	18.1 ± 0.6† (18.0-18.2)	42.0 ± 2.2*†‡ (41.6-42.4)			

Values are presented as mean $\pm$ standard deviation (95% confidence interval). Differences were analyzed using two-way mixed ANOVA with sex as a between-subject factor and pass length as a within-subject factor. Effect sizes are reported as partial eta squared (η^2). * – significant difference compared to men within the same pass length ($p < 0.05$). †, ‡ – significant difference compared to short and medium within the same sex, respectively ($p < 0.05$).



(A) Distribution of passes across pitch zones (defensive third [DT], middle third [MT], and attacking third [AT]) for men and women. Values are expressed as percentages of total passes. (B) Pass completion rate (%) for each pitch zone in men and women. Data are presented as mean $\pm$ standard deviation. * – Significant difference between men and women within the same pitch zone ($p < 0.05$). d, m – significant difference compared with the defensive and middle third within the same sex, respectively ($p < 0.05$).

Fig. 2. Sex differences in pass distribution and completion rate across pitch zones.

A significant interaction between sex and pitch zone was observed for pass counts ($p < 0.01$) (Tab. 3), suggesting that sex differences varied across pitch zones. Simple effects analysis revealed that women performed fewer passes than men in the DT and MT, whereas no significant difference emerged in the AT (Tab. 3). For pass completion rate, no clear interaction was observed ($p = 0.05$), indicating that sex differences were relatively consistent across pitch zones. A significant main effect of sex was observed, with women showing lower completion rates overall (Tab. 3, Fig. 2B). Mean pass distance varied across pitch zones, with relatively small differences between sexes (Tab. 3).

A significant multivariate effect of sex was observed for pass length distribution within each pitch zone (Wilks' $\Lambda = 0.88$, $F(6, 249) = 5.58$, $p < 0.001$, $\eta^2 = 0.12$), indicating that sex differences in pass distribution depended on both pass length and pitch

zone (Fig. 3A). Across pitch zones, sex differences in pass length distribution varied by location. In the DT and MT, women showed a higher proportion of short passes and a lower proportion of medium passes than men, whereas differences in long-pass proportion were minimal. In the AT, there was no meaningful difference for short and long passes, while the proportion of medium passes was slightly lower in women (Fig. 3A).

A significant three-way interaction between sex, pass length, and pitch zone was observed for all variables (all $p < 0.05$) (Tab. 4), indicating that sex differences in passing performance depended on the combination of pass length and pitch zone. Given this interaction, simple effects were examined within each pitch zone (Tab. 5, Fig. 3B).

Table 3. Sex differences in passing performance across pitch zones.

Variables	Pitch Zone			p-value of 2-way ANOVA (partial η^2)		
				Interaction (Sex $\times$ Pitch Zone)	Main effect	
	DT (95%CI)	MT (95%CI)	AT (95%CI)		Sex	Pitch Zone
Number of passes, n						
Men	132.3 $\pm$ 36.1 (126.0-138.6)	237.3 $\pm$ 100.9 ^d (219.6-254.9)	101.9 $\pm$ 49.4 ^{dm} (93.3-110.5)	< 0.01 (0.02)	< 0.001 (0.05)	< 0.001 (0.59)
Women	115.4 $\pm$ 36.3* (109.0-121.7)	196.0 $\pm$ 90.0* ^d (180.3-211.8)	88.9 $\pm$ 57.2 ^{dm} (78.9-98.9)			
Completion rate, %						
Men	81.5 $\pm$ 8.0 (80.1-82.9)	84.7 $\pm$ 6.6 ^d (83.6-85.9)	72.2 $\pm$ 7.0 ^{dm} (71.0-73.4)	0.05 (0.01)	< 0.001 (0.23)	< 0.001 (0.50)
Women	72.9 $\pm$ 12.4* (70.8-75.1)	74.0 $\pm$ 9.9* (72.3-75.7)	63.9 $\pm$ 10.2* ^{dm} (62.2-65.7)			
Distance, m						
Men	23.9 $\pm$ 2.5 (23.4-24.3)	20.2 $\pm$ 1.6 ^d (19.9-20.4)	16.3 $\pm$ 1.5 ^{dm} (16.1-16.6)	< 0.01 (0.03)	< 0.001 (0.06)	< 0.001 (0.80)
Women	22.6 $\pm$ 2.5* (22.1-23.0)	19.8 $\pm$ 1.6 ^d (19.6-20.1)	16.1 $\pm$ 1.8 ^{dm} (15.8-16.4)			

DT – defensive third; MT – middle third; AT – attacking third. Values are presented as mean $\pm$ standard deviation (95% confidence interval). Differences were analyzed using two-way mixed ANOVA with sex as a between-subject factor and pitch zone as a within-subject factor. Effect sizes are reported as partial eta squared (η^2). * – significant difference compared to men within the same pitch zone ($p < 0.05$). ^{d, m} – significant difference compared to defensive and middle third within the same sex, respectively ($p < 0.05$).

Table 4. Results of three-way ANOVA for passing performance variables.

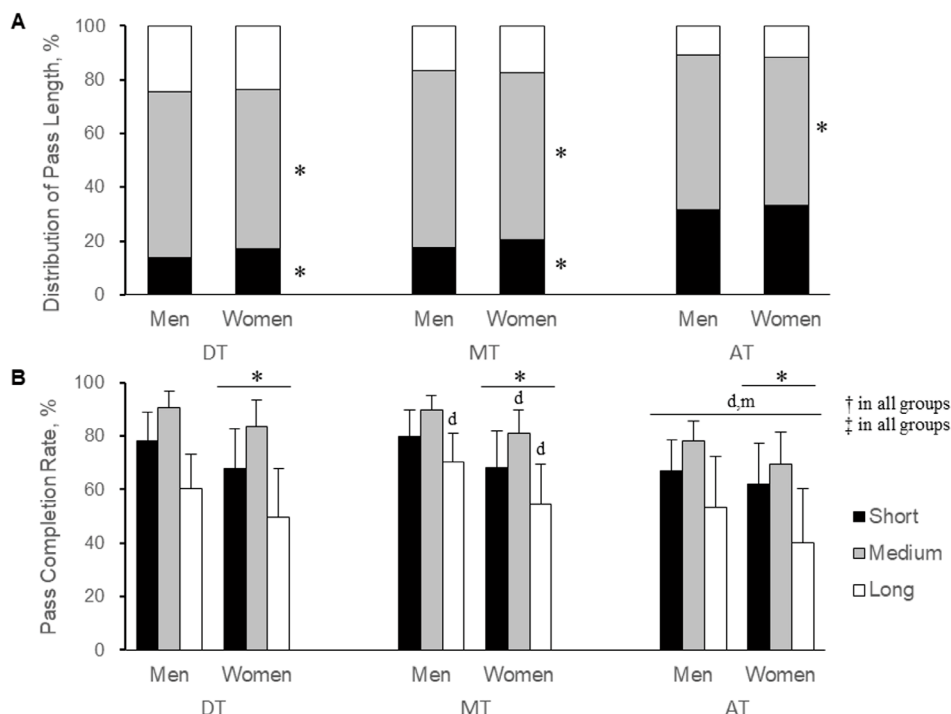
Effect	df1	df2	F-value	p-value	partial η^2
Number of passes					
Sex	1.00	254.00	14.08	< 0.001	0.05
Pass Length	1.11	281.09	932.79	< 0.001	0.79
Pitch Zone	1.58	401.29	366.46	< 0.001	0.59
Sex $\times$ Pass Length	1.11	281.09	13.83	< 0.001	0.05
Sex $\times$ Pitch Zone	1.58	401.29	5.32	< 0.01	0.02
Pass Length $\times$ Pitch Zone	1.74	442.51	331.32	< 0.001	0.57
Sex $\times$ Pass Length $\times$ Pitch Zone	1.74	442.51	7.71	< 0.01	0.03
Completion rate					
Sex	1.00	254.00	109.42	< 0.001	0.30
Pass Length	1.77	449.6	1059.15	< 0.001	0.81
Pitch Zone	1.74	441.66	220.68	< 0.001	0.46
Sex $\times$ Pass Length	1.77	449.6	9.78	< 0.001	0.04
Sex $\times$ Pitch Zone	1.74	441.66	3.56	< 0.05	0.01
Pass Length $\times$ Pitch Zone	3.01	763.94	15.94	< 0.001	0.06
Sex $\times$ Pass Length $\times$ Pitch Zone	3.01	763.94	3.12	< 0.05	0.01
Distance					
Sex	1.00	254.00	45.28	< 0.001	0.15
Pass Length	1.15	292.02	41347.69	< 0.001	0.99
Pitch Zone	1.68	427.83	289.07	< 0.001	0.53
Sex $\times$ Pass Length	1.15	292.02	23.72	< 0.001	0.09
Sex $\times$ Pitch Zone	1.68	427.83	2.61	0.08	0.01
Pass Length $\times$ Pitch Zone	1.86	473.38	101.02	< 0.001	0.28
Sex $\times$ Pass Length $\times$ Pitch Zone	1.86	473.38	32.76	< 0.05	0.01

Results are presented as F-values with corresponding degrees of freedom (df1, df2), p-values, and partial eta squared (η^2). A three-way mixed ANOVA was conducted with sex as a between-subject factor and pass length and pitch zone as within-subject factors. Degrees of freedom for within-subject effects were corrected using the Greenhouse–Geisser adjustment when the assumption of sphericity was violated.

Table 5. Combined effects of sex, pass length, and pitch zone on passing performance variables

Variables		DT (95%CI)	MT (95%CI)	AT (95%CI)
Number of passes, n				
Men	Short	17.9 ± 6.7 (16.8-19.1)	40.2 ± 16.1 (37.4-43.1) ^d	31.8 ± 15.5 (29.1-34.5) ^{dm}
	Medium	82.9 ± 28.0 (78.0-87.8) [†]	159.3 ± 79.0 (145.5-173.1) ^{†d}	59.3 ± 32.1 (53.7-64.9) ^{†dm}
	Long	31.5 ± 8.9 (29.9-33.1) ^{††}	37.7 ± 14.3 (35.2-40.2) ^{†d}	10.8 ± 5.8 (5.8-11.8) ^{††dm}
Women	Short	19.2 ± 7.7 (17.8-20.5)	36.5 ± 13.5 (34.1-38.8) ^{*d}	28.9 ± 17.5 (25.9-32.0) ^{dm}
	Medium	69.9 ± 29.3 (64.8-75.0) ^{*†}	126.5 ± 68.4 (114.5-138.4) ^{*†d}	50.1 ± 35.9 (43.9-56.4) ^{*†dm}
	Long	26.3 ± 9.0 (24.7-27.9) ^{*††}	33.1 ± 14.8 (30.5-35.7) ^{*†d}	9.8 ± 6.0 (8.8-10.9) ^{††dm}
Completion rate, %				
Men	Short	78.0 ± 11.0 (76.1-79.9)	80.0 ± 9.8 (78.3-81.7)	66.9 ± 11.7 (64.9-69.0) ^{dm}
	Medium	90.6 ± 6.2 (89.6-91.7) [†]	89.7 ± 5.7 (88.7-90.7) [†]	78.2 ± 7.3 (76.9-79.5) ^{†dm}
	Long	60.4 ± 12.8 (58.2-62.6) ^{††}	70.2 ± 10.9 (68.2-72.1) ^{††d}	53.3 ± 18.9 (50.0-56.6) ^{††dm}
Women	Short	67.9 ± 14.9 (65.3-70.5) [*]	68.1 ± 13.7 (65.7-70.5) [*]	61.9 ± 15.3 (59.2-64.6) ^{*dm}
	Medium	83.4 ± 10.1 (81.7-85.2) ^{*†}	81.0 ± 9.0 (79.4-82.6) ^{*†d}	69.7 ± 11.8 (67.6-71.7) ^{*†dm}
	Long	49.6 ± 18.4 (46.4-52.8) ^{*††}	54.8 ± 14.8 (52.2-57.4) ^{*††d}	40.2 ± 20.2 (36.7-43.7) ^{*††dm}
Distance, m				
Men	Short	7.0 ± 0.7 (6.8-7.1)	7.2 ± 0.5 (7.1-7.3) ^d	6.6 ± 0.6 (6.5-6.7) ^{dm}
	Medium	19.0 ± 0.8 (18.8-19.1) [†]	18.0 ± 0.6 (17.9-18.1) ^{†d}	17.1 ± 0.9 (17.0-17.3) ^{†dm}
	Long	45.3 ± 3.8 (44.6-46.0) ^{††}	42.2 ± 2.4 (41.8-42.6) ^{††d}	40.2 ± 3.8 (39.5-40.8) ^{††dm}
Women	Short	6.7 ± 0.8 (6.6-6.8) [*]	6.8 ± 0.6 (6.7-6.9) [*]	6.5 ± 0.7 (6.3-6.6) ^{*dm}
	Medium	18.8 ± 0.9 (18.7-19.0) [†]	18.0 ± 0.8 (17.9-18.2) ^{†d}	17.3 ± 1.1 (17.1-17.4) ^{†dm}
	Long	43.3 ± 3.6 (42.7-43.9) ^{*††}	41.5 ± 2.1 (41.1-41.9) ^{*††d}	38.1 ± 4.7 (37.3-38.9) ^{*††dm}

DT – defensive third; MT – middle third; AT – attacking third. Values are presented as mean ± standard deviation (95% confidence interval). Differences were analyzed using three-way mixed ANOVA with sex as a between-subject factor and pass length and pitch zone as within-subject factors. Effect sizes are reported as partial eta squared (η^2). * – significant difference compared to men within the same pass length and pitch zone ($p < 0.05$). †, ‡ – significant difference compared to short and medium passes within the same sex, respectively ($p < 0.05$). d, m – significant difference compared to defensive and middle third within the same sex, respectively ($p < 0.05$).



(A) Distribution of passes across pass length categories (short, medium, and long) within each pitch zone (defensive third [DT], middle third [MT], and attacking third [AT]) for men and women. Values are expressed as percentages of total passes. (B) Pass completion rate (%) for each pass length category within each pitch zone in men and women. Data are presented as mean ± standard deviation. * – significant difference between men and women within the same pass length category and pitch zone ($p < 0.05$). †, ‡ – significant difference compared with short and medium passes within the same sex and pitch zone, respectively ($p < 0.05$). d, m – significant difference compared with the defensive and middle third within the same sex and pass length, respectively ($p < 0.05$).

Fig. 3. Combined effects of pass length and pitch zone on passing performance.

For the number of passes, women performed fewer medium and long passes than men in the DT, fewer passes than men across all pass length categories in the MT, and fewer medium passes than men in the AT (Tab. 5). For pass completion rate, women showed lower values than men across all pass length categories in the DT ($p < 0.05$). In the MT and AT, women also exhibited lower completion rates than men across pass lengths ($p < 0.05$) (Tab. 5 and Fig. 3B). For pass distance, women showed shorter distances than men for short and long passes in the DT, while no clear differences were observed for medium passes. In the MT and AT, sex differences in pass distance were also observed, similar to those in the DT (Tab. 5). These results indicate that sex differences in passing performance varied depending on both pass length and pitch zone and were observed in specific combinations of these factors rather than uniformly across all conditions.

Discussion

This study comprehensively examined sex differences in passing performance using match data from the 2022 FIFA Men's World Cup and the 2023 FIFA Women's World Cup. Previous comparative studies of men's and women's football have reported sex differences in pass completion rates and technical indicators [3, 18]; however, multidimensional analyses integrating pass length and pitch zones remain limited. The main findings of this study were that men attempted significantly more passes and achieved higher pass completion rates than women. In addition, women showed a relatively higher proportion of short passes and a lower proportion of medium passes. With respect to pitch zones, sex differences were evident in the defensive and middle thirds, whereas no clear differences were observed in the attacking third. Furthermore, a significant three-way interaction between sex, pass length, and pitch zone was observed for all variables, indicating that sex differences in passing performance are context-dependent.

The large sex difference in pass completion rate (Cohen's $d = 1.22$) is generally consistent with previous findings. Iván-Baragaño et al. reported large effect sizes for accurate passes ($ES = 0.97$) and conceded goals ($ES = 1.19$) in their data-mining analysis of elite men's and women's football [18], supporting the substantial effect observed in the present study. Similarly, Luca Pappalardo et al. reported that women tend to exhibit lower technical performance indicators than men based on large-scale data analyses [3]. In contrast, Yang & Kolbinger found no significant differences in several passing network metrics when comparing domestic leagues in England, suggesting that collective coordination structures may be similar between sexes [16]. These discrepancies indicate that the magnitude of sex differences may depend on competition level and tournament context. The observed differences in pass completion rate may be explained by a combination of factors, including a higher risk of turnovers faced by women players [18], as well as differences in off-ball movement and defensive pressure reported in women's World Cup matches [17], which may influence passing options and receiver availability. Furthermore, Caicedo-Parada et al. highlighted that passing behavior is influenced by various contextual factors such as match situations and opponent strategies [9], suggesting that the observed sex differences should be interpreted as the result of multiple interacting factors.

Regarding pass length distribution, women exhibited a higher proportion of short passes and a lower proportion of medium passes, whereas no clear difference was observed in long passes (Fig. 1A). The significant multivariate effect (Wilks' $\Lambda =$

0.92 , $F(2,253) = 11.46$, $p < 0.001$, $\eta^2 = 0.08$) indicates qualitative differences in passing strategies between men and women. The higher proportion of short passes in women may reflect a risk-management strategy aimed at minimizing turnovers. Król et al. reported that higher possession teams tended to achieve greater success in short and medium passes during the 2014 FIFA World Cup [2], suggesting that short passing contributes to possession stability. The reasons for the lower proportion of medium passes in women are likely more complex. One possible explanation may be differences in build-up structure, which have previously been described as more direct styles of play in women's football [17]. In a direct style of play, teams may favor a rapid transition from short passing sequences to longer passes rather than engaging in medium-range build-up play. However, in the present study, no clear sex differences were observed in the proportion of long passes. This suggests that "directness" in women's football may not necessarily be characterized by an increased use of long passes, but rather by shorter passing sequences and a reduced reliance on medium-range build-up play. The discrepancy with findings from domestic league studies [16] may be explained by the heterogeneity of teams in World Cup tournaments, where teams from different developmental backgrounds compete together [17].

In the analysis by pitch zone, women attempted significantly fewer passes than men in the DT and MT, whereas no clear difference was observed in the AT. In contrast, no significant multivariate effect was found for pass distribution across pitch zones (Wilks' $\Lambda = 0.99$, $F(2,253) = 1.24$, $p = 0.29$), indicating similar spatial distributions of passing between men and women. The reduced number of passes in the DT and MT in women may reflect differences in build-up strategies, where men may emphasize ball circulation from deeper areas to construct attacks [14], whereas women may adopt approaches that involve fewer passes in these zones [17]. The absence of differences in the AT suggests that passing patterns in the final phase of attack may be similar between sexes, consistent with previous findings that passing behavior in advanced areas exhibits distinct characteristics [15]. For pass completion rate, the non-significant interaction between sex and pitch zone ($p = 0.05$) and the presence of a significant main effect of sex indicate that differences in completion rate were consistent across pitch zones.

A key contribution of this study is the identification of a significant three-way interaction between sex, pass length, and pitch zone. In the DT and MT, women showed a higher proportion of short passes and a lower proportion of medium passes, whereas this pattern was less evident in the AT, where only medium passes were slightly lower in women. In addition, pass completion rates were consistently lower in women across all combinations of pass length and pitch zone. These findings demonstrate that statements such as "women use more short passes" or "women have lower pass success rates" vary depending on tactical context. Therefore, multidimensional analyses are necessary to capture these complex patterns. This aligns with previous research emphasizing the context-dependent nature of passing behavior [9] and highlights the importance of integrated analytical approaches in comparative studies of men's and women's football.

Several limitations should be acknowledged. First, the data were limited to a single tournament, preventing longitudinal comparisons. Norton et al. reported that tactical styles in men's World Cup tournaments vary across competitions [26], and therefore it remains unclear whether the findings of the present study can be generalized to other tournaments or time periods. Second, because each match contributed two team observa-

tions, complete statistical independence between observations cannot be assumed. Third, contextual factors such as match status, opponent strength, and tactical pressure were not controlled. Furthermore, the use of aggregated event data does not allow direct assessment of contextual variables such as pressure conditions or available passing options. Future studies should incorporate longitudinal designs, individual-level tracking data, and contextual variables to better understand the mechanisms underlying sex differences in passing performance. Comparative analyses across different competition levels and confederations are also needed to clarify the generalizability of these findings.

Conclusions

This study demonstrated that sex differences in passing performance exist in elite international football; however, these differences are not uniform and vary depending on pass length and pitch zone. The findings highlight the importance of considering tactical context when evaluating sex differences in football performance and provide new insights into the multidimensional nature of passing behavior in men's and women's football.

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