

# All Things Being Equal: Spatiotemporal Differences between Open and Women's 16-Goal Polo

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## 25 **Summary**

26 Polo is an equestrian team sport, consisting of Open and Women's only handicapping systems. As  
27 cumulative player handicap increases in Open Polo, distance covered, average speeds and high  
28 intensity work performed per chukka also increase. These activities may differ in terms of  
29 distribution of, and their affect upon, match outcome in Women's Polo, and thus have implications  
30 for equine preparation and management.

31 To quantify spatiotemporal differences between Open and Women's Polo when matched for  
32 handicap and assess their affect upon chukka and match outcome using a prospective cohort  
33 design. Distance, speed and high intensity activity data were collected via player worn global  
34 positioning system (GPS) units during 16-goal Open and Women's Polo tournaments. Notational  
35 analysis quantified chukka duration and chukka and game outcomes. Between group differences  
36 were assessed by independent samples *t*-tests, and two factor mixed effects ANOVA for within  
37 group analyses. Between group differences were analysed using an independent samples *t*-test with  
38 alpha defined *a priori* as  $p < 0.05$ .

39 Open and Women's Polo differed by a *small to large* extent (ES: 0.54 – 1.81) for all spatiotemporal  
40 metrics. In Open Polo, players covered *moderately* more distance (429.0m; 238.9m to 619.0m),  
41 with *small to large* increases in high intensity activities performed in games won. Whereas in  
42 Women's Polo, *moderately* higher maximum speeds were attained in games won (17.13 km/h;  
43 11.86 km/h to 22.40 km/h) and a *small* increase in accelerations performed (5.1; 0.2 to 10.0).

44 Open and Women's Polo, when matched for handicap, present with *small to large* spatiotemporal  
45 differences that are likely of practical significance, and influence game outcome differently  
46 between codes. These differences do not necessarily mean that Polo ponies need to be trained  
47 differently for each code.

48

## 49 **Introduction**

50 Polo is an equestrian team sport contested by two teams of four players. Play is divided into seven-  
51 minute chukkas, and a player must change horses between chukkas, to ensure adequate equine  
52 physiological recovery [1-3]. Individual handicaps are awarded from -2 to +10 goals, with level  
53 of play dictated by the cumulative handicap of each member of a team [3,4]. Female players can  
54 hold parallel Open and Women's handicaps, despite being scored on the same variables these  
55 handicaps are weighted differently e.g. a female player may be an Open 4-goal player, but 10-  
56 goals in Women's Polo. The reason for implementing a parallel system is to account for  
57 compression brought about by increased participation in women's Polo internationally [5]. This  
58 allows for greater differentiation between female players, with a similar Open handicap, with  
59 Women's handicaps usually higher than an equivalent open handicap [6].

60 Previously, we have shown increases in average speed attained and distance covered per chukka  
61 [7] as cumulative handicap increases in Open Polo; cumulative handicap may also affect high  
62 intensity activities [7], imposing additional internal physiological loads upon horses and players  
63 [8-12]. Thus, an understanding of the equine demands of Women's Polo is required. At present  
64 these demands are unknown and there may be important points of difference to Open Polo, that  
65 may affect equine preparation for Polo participation, and in game horse management strategies.  
66 Hence, the aim of this study is to explore the differences in spatiotemporal characteristics between  
67 handicap-matched levels of Open and Women's Polo, and to quantify the relationship between  
68 spatiotemporal characteristics and match outcomes in Open and Women's Polo.

## 69 **Methods**

70 All data collection took place over the 2018-2019 New Zealand Polo season, specifically at two  
71 16-goal tournaments; one open and one women's tournament, employing a cross sectional design.  
72 Handicaps were as awarded by the New Zealand Polo Association. Women's equivalent Open  
73 handicaps were sourced from the New Zealand, Australian and Hurlingham Polo Associations.  
74 Ethical approval for this investigation was provided by Waikato Institute of Technology's  
75 (Wintec) ethics committee (Approval code: WTFE2601102018), and as per the International  
76 Guiding Principles for Biomedical Research Involving Animals as issued by the Council for the  
77 International Organizations of Medical Sciences. Data for the present study are freely available  
78 online [13].

79

### 80 *Sample population*

81 This study comprised observations from two distinct playing groups: two open teams and three  
82 women's teams – both groups played in the 16-goal sections of their respective tournaments. Open  
83 participants consisted of eight Polo players (7 males and 1 female; Handicap range 0–7 goals),  
84 whereas women's participants consisted of 12 female Polo players (Handicap range 0–10 goals).  
85 Handicaps of individual players are listed in Table 1. Prior to study involvement, informed consent  
86 was obtained from players and owners.  
87 Players selected their own strings of ponies, with ponies stabled either truck-side or in open air  
88 yards prior to playing. Warm up and feeding protocols were at the players' and grooms' discretion.  
89 Playing distribution and strategy of Polo ponies within a player's string was also at the discretion  
90 of each player.

91

## 92 *Data collection procedures*

93 Data were collected from a total of 258 chukkas across both Open and Women's Polo tournaments  
94 (n = 130 and n = 128, respectively; no *a priori* sample size calculations were performed but this  
95 represents two entire tournaments across multiple teams) using player worn GPS monitors (VX  
96 Sport) set to equestrian mode with a sampling frequency of 10 Hz and a speed range of 0 – 60  
97 km/h. We have previously shown this method to produce reliable results for the metrics assessed  
98 in the present investigation [10], when mounted either between the players' shoulders or worn on  
99 players' belts.

100 GPS units were turned upon arrival at the playing venues to obtain an initial satellite lock and were  
101 then turned on again 30 min prior to the start of games, to ensure a secure connection to multiple  
102 satellites was established. All players opted to wear GPS units in a pouch fixed to their belts. The  
103 belt pouch was secured with insulation tape to minimise oscillation of the unit during games. Upon  
104 game completion, units were turned off and data downloaded using specialist software as provided  
105 by the manufacturer (VX Sport). The initial satellite lock period was trimmed from the data, and  
106 the game period was divided into chukkas as per an accompanying notational analysis to normalise  
107 data for between and within groups analyses. Speed zones using in-built software thresholds were  
108 derived as follows: Zone 1: 0–19.2 km/h; Zone 2: 19.2–23.4 km/h; Zone 3: 23.4–28.2 km/h; Zone  
109 4: 28.2–47.4 km/h; and Zone 5: 47.4–60 km/h. Total distance (m), distance covered (m) in each  
110 speed zone, the number of accelerations, decelerations, impacts and sprints were selected as  
111 dependent variables from the GPS output (metrics defined as per [13]), with chukka duration  
112 (min:s) reported from the notational analysis. Data were then exported to Microsoft Excel for  
113 further analysis as detailed below. Players were provided with a brief data analysis and feedback  
114 following each tournament.

115

116 *Statistical Analyses*

117 Data were considered normally distributed if they passed the mean and SD test ( $2 \times \text{SD} > \text{mean}$ ), or  
118 if the mean and median were within 10% of each other. Following these tests, homogeneity and  
119 sphericity between group differences were analysed using an independent samples t-test with alpha  
120 defined *a priori* as  $p < 0.05$ . A two factor mixed effects ANOVA was used to assess the effect of  
121 chukka (win/loss) and game outcomes (win/loss) upon spatiotemporal characteristics, at the same  
122 alpha level. It should be noted that the absence of statistical significance does not signify lack of  
123 practical importance, with respect to Polo performance. All analytical procedures were computed  
124 using SPSS (v24). Effect sizes for between group comparisons (Cohen's *d*) and accompanying  
125 95% confidence intervals (C.I.) were calculated using a customised spreadsheet. Magnitudes of  
126 effect were interpreted using the descriptors suggested by Hopkins et al., [14]. An effect was  
127 deemed unclear if its confidence interval crossed zero and the threshold for a *small* effect [15]. For  
128 within group comparisons (chukka and game win loss outcomes) data are reported as raw  
129 differences between outcomes with accompanying 95% confidence intervals, effect sizes (Cohen's  
130 *d*) and magnitude-based descriptors.

131

## 132 **Results**

133 Significant differences between Open and Women's Polo were found for all spatiotemporal  
134 characteristics assessed, although these differences varied in terms of magnitude (*Small to Very*  
135 *Large*); as presented in Table 2, with differences per speed zone between Open and Women's play  
136 shown in Figure 1. Significant results of two factor mixed effects ANOVAs are grouped by metrics  
137 and reported for Open and Women's play in the subsections below. Complete results can be found  
138 in supplementary material Tables 1 and 2 for Open and Women's Polo, respectively.

139

### 140 *Distance metrics*

141 There were *large* differences (ES: 1.54; 95% CI: 1.26 to 1.81) in total distance covered per chukka  
142 between Open and Women's Polo. Between groups differences for independent speed zones 1 – 5  
143 are presented in Figure 1. In Open Polo, distance per chukka was significantly influenced by both  
144 chukka ( $F(1,126) = 5.80; p = 0.018$ ) and game ( $F(1,126) = 19.95; p < 0.001$ ) outcomes, with  
145 winning chukkas showing a *small* reduction in distance covered (-231.2m; -421.3m to -41.2m) but  
146 *moderately* more distance covered in games won (429.0m; 238.9m to 619.0m). Whereas, in  
147 women's Polo neither chukka nor game outcome significantly affected total distance per chukka,  
148 but there was a significant interaction between chukka and game outcome with respect to total  
149 distance. More specifically, distance covered in speeds zones 1 ( $F(1,126) = 28.47; p < 0.001$ ), 2  
150 ( $F(1,126) = 4.29; p < 0.041$ ) and 5 ( $F(1,126) = 5.18; p < 0.025$ ) in Open Polo were significantly  
151 affected by game outcome, whereas in Women's Polo only distance covered in speed zone 4  
152 showed a chukka by game interaction ( $F(1,124) = 2.01; p = 0.017$ ).

153

### 154 *Speed metrics*

155 Absolute maximum speeds for Open and Women's play were 61.5 and 59 km/h respectively, with  
156 *large* differences in average maximum speeds ( $p < 0.001$ , Table 2) between groups but only *small*

157 differences in average playing speed ( $p = 0.019$ ; Table 2). Maximum speed data for each category  
158 of play are shown in Figure 2 to demonstrate the distribution of maximal speeds between groups.  
159 A *small* reduction in average speed (-1.37 km/h; -2.33 km/h to -0.40 km/h) was seen in winning  
160 games in Open Polo ( $F(1,126) = 7.91$ ;  $p = 0.006$ ), whereas in Women's Polo maximum speed was  
161 *moderately* higher (17.13 km/h; 11.86 km/h to 22.40 km/h;  $F(1,124) = 41.40$ ;  $p < 0.001$ ).

162

### 163 *High intensity metrics*

164 *Small to Large* differences between Open and Women's Polo were found for all high intensity  
165 activities (all  $p \leq 0.001$ ; Table 2). Within Open Polo, more sprints (8.3; 5.9 to 10.7), accelerations  
166 (7.6; 2.4 to 12.9) and decelerations (7.0; 2.0 to 11.9) were performed in games won (all  $p \leq 0.006$ ),  
167 but their effect upon chukka outcome was unclear. Conversely, in Women's Polo a *small* increase  
168 in accelerations (5.1; 0.2 to 10.0) were performed in games won ( $p = 0.041$ ). Despite differing  
169 between groups (Table 2), the role of impacts in chukka or game outcome was either *trivial* or  
170 *unclear*.

171

### 172 *Duration*

173 Chukka durations differed significantly ( $p < 0.001$ ) between Open and Women's Polo by a *large*  
174 extent. In Open Polo, chukkas won were significantly ( $p = 0.017$ ) shorter by a *small* extent (-01:06;  
175 95% C.I. -02:00 to -00:11), despite games won being *moderately* longer than games lost (02:45;  
176 01:51 to 03:39;  $p < 0.001$ ). In Women's Polo, however, the difference in duration between games  
177 won and lost was *small* (00:40; 00:02 to 01:17;  $p = 0.037$ ), with no statistically significant  
178 difference between chukkas won or lost.

179



## 180 Discussion

181 This investigation aimed to assess the differences in spatiotemporal characteristics between  
182 handicap-matched levels of Open and Women's Polo. With a secondary aim of assessing the effect  
183 of chukka and game outcome upon spatiotemporal characteristics in Open and Women's Polo.  
184 Between group comparisons (Table 2) showed statistically significant differences between Open  
185 and Women's Polo for all spatiotemporal characteristics (all  $p \leq 0.001$ ), with differences ranging  
186 in magnitude from *small* to *large*. Of importance are the *large* differences in chukka duration  
187 between groups and the nearly 700m discrepancy in total distance covered per chukka when  
188 Women's Polo is compared to Open play. Whilst distance covered only differed by a *trivial* extent  
189 in games won and lost in Women's Polo, distance covered was *moderately* greater in games won  
190 (429.0; 238.9 to 619.0) and reported a significant chukka by game interaction ( $p = 0.049$ )  
191 suggesting that covering more ground than one's opponents in at least one chukka resulted in a  
192 greater win rate. The same interaction effect is seen in Women's Polo, but the magnitude of this  
193 interaction is *small*, this is likely driven by the lesser distance covered per chukka in Women's  
194 Polo, and the bidirectional nature of confidence limits for chukka and game outcomes. The  
195 implications of these findings upon Polo horse preparation and management during games are  
196 explored throughout this discussion.

197 The differences in distance between groups are further emphasised by Figure 1. Women's Polo  
198 displays a U-like distribution with broad error bars especially in speed zone 4 (0–1622m), whereas  
199 Open Polo represents an inverted-U with greater consistency within the velocities attained.  
200 Practically, this indicates very different rhythms of play; Open Polo is characterised by a  
201 maintenance of a cruising velocity with relatively little distance accumulated at low or near  
202 maximal speeds. Most accelerations and decelerations may also occur within this speed zone,  
203 hence its emphasis. High speeds are still consistently attained though (Figures 1 and 2), suggesting  
204 these maximal efforts may take place with a shorter lead in (i.e. greater rates of acceleration) and

205 serve a different tactical purpose in comparison to Women's Polo. Speed shows a more polarised  
206 distribution (Fig.1) of a seemingly stochastic nature in Women's Polo; accompanying error  
207 margins (Fig.1 and 2) highlight that whilst players may be physically and technically proficient  
208 [16], their ponies must also be physically conditioned to cope with a slow/fast playing style. Such  
209 conditioning may take the form of high intensity interval training [13,17,18], although this has  
210 been noted to be potentially injurious in thoroughbreds [18]. Injury may also occur in s if the  
211 relationship between speed and limb force exceeds a critical limit during turns [19] but Polo ponies  
212 typically display a greater tolerance to this and can turn in tighter circles than race horses [19].  
213 Irrespective of the source, injury risk must be minimised by appropriate loading of ponies [20,21]  
214 playing in either Open or Women's Polo, due to the relatively high acceleration, deceleration and  
215 sprint counts sustained per chukka (Table 2).

216 Maximum speeds significantly differed ( $p < 0.001$ ) between groups (*Large*; 1.39; 1.22 to 1.69),  
217 also showing markedly different distributions and ranges (Figure 2). Higher maximum speeds may  
218 still be of practical or tactical importance in Women's Polo despite higher speeds being attained  
219 more frequently and consistently in Open Polo. Hence, training for both Open and Women's Polo  
220 should expose ponies to near maximal velocities, to ensure adequate speed capacity, condition  
221 ponies to game demands and minimise the risk of injury [20,21]. By extension, Polo ponies should  
222 also be conditioned to perform high intensity activities as more sprints, accelerations and  
223 decelerations were performed in games won than in games lost, despite differing by a *small* to  
224 *large* extent between Open and Women's Polo ( $p \leq 0.001$ ). Indeed, such movements likely impact  
225 upon the health of the horse's lower limb, with tendon injuries frequently reported in Polo  
226 [7,22]. Such injury is likely due to repetitive eccentric loading across multiple joints [23] brought  
227 about by simultaneous braking and turning forces [24,25], attention should also be paid to the  
228 speed at which these movements are trained [19] to minimise injury risk, regardless of code of  
229 Polo played.

230 Collectively, these data support the use of a parallel handicap system for Women's Polo due to  
231 differences observed in distribution of playing speeds (Fig. 1), typical distances covered per  
232 chukka (Table 2) and the greater variability within these characteristics (Fig.1 and 2). These  
233 spatiotemporal differences are likely accompanied by differences in technical proficiency and  
234 tactical behaviours, evidenced in part by differences in Open handicap (Table 1), which likely  
235 contribute to chukka and game outcomes alongside the differences in spatiotemporal  
236 characteristics identified in the present study. Concomitant measures of internal load such as horse  
237 heart rate would also be of value in assessing the physiological consequences of distances covered  
238 per speed zone. It is unclear whether spatiotemporal differences of the present magnitudes signify  
239 a genuine need to prepare ponies differently for Open and Women's Polo, or more likely that  
240 ponies should be managed differently in games e.g. opting to half chukka ponies in Open Polo.  
241 A possible limitation is that some of these differences may be perceived as occurring simply due  
242 to differences in average chukka length. Whilst some influence cannot be ruled out, it is unlikely  
243 the sole explanatory factor as the most likely explanation for longer chukkas would either be due  
244 to the ball going out of play more frequently, conceding of more penalties by either team or injuries  
245 sustained by a player or horse. These incidents all slow down Polo play, therefore fewer metres  
246 are accrued in higher speed zones, so the differences between Open and Women's play have  
247 occurred in spite of longer chukka lengths in Open Polo. A further limitation of this study is the  
248 use of player worn GPS, whilst this is the most feasible strategy for Polo due to multiple horse  
249 changes [10], it means braking and turning forces cannot be calculated at the joint and thus our  
250 work does not directly support that of Tan and Wilson [19] who calculated the forces experienced  
251 by turning Polo ponies. However, due to the high volume of turning and braking movements  
252 performed per chukka, and games played per season, we recommend prudent preparation of ponies  
253 within a periodised Polo training programme that progressively exposes ponies to the intensities  
254 and movement requirements of in-season play.

255 In conclusion, Open and Women's Polo, when matched for their cumulative handicaps, present  
256 with *small to large* spatiotemporal differences that may be of practical and statistical significance.  
257 Within Polo codes, a greater number of variables were affected by game and chukka outcome in  
258 Open Polo, whereas in Women's Polo fewer variables were associated with chukka or game  
259 outcome. A further point of difference was the distribution of distance covered within playing  
260 speed zones (Figure 1) and maximal speeds attained (Figure 2). These differences, whilst likely of  
261 practical importance on the Polo pitch and further influenced by players' technical proficiency, do  
262 not necessarily mean that Polo ponies need to be trained differently for each code. We recommend  
263 the incorporation of sufficient aerobic development to cover between 2500 – 3000m per chukka,  
264 and progressive exposure to high speeds and braking and turning forces during preparation for  
265 Polo, irrespective of whether one is playing Open or Women's Polo.

266

#### 267 **Manufacturers details:**

268 SPSS: (v24, IBM, United States)

269 VX Sport: (350, Lower Hutt, New Zealand)

270

#### 271 **Supplementary legends:**

272 **Supplementary 1:** Results of factorial ANOVA for Open Polo; Significant *p* values are presented  
273 in bold. All raw differences are calculated as WIN-LOSS. Raw differences are not provided for  
274 interaction effects. Magnitudes of effect sizes are denoted by the following symbols: \*: Small; #  
275 Moderate; †: Large; ‡: Very Large

276 **Supplementary 2:** Results of factorial ANOVA for Women's Polo; Significant *p* values are  
277 presented in bold. All raw differences are calculated as WIN-LOSS. Raw differences are not  
278 provided for interaction effects. Magnitudes of effect sizes are denoted by the following symbols:  
279 \*: Small; # Moderate; †: Large; ‡: Very Large

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352

353

354 **Table 1 Player Handicaps (goals) for Open and Women's handicaps. Male Open players are not eligible for a**  
 355 **Women's handicap but all female players have both an Open and Women's handicap.**

Team	Player #	Open handicap	Women's handicap
<i>Open 1</i>	1	0	N/A
	2	4	10
	3	5	N/A
	4	7	N/A
<i>Open 2</i>	1	2	N/A
	2	3	N/A
	3	6	N/A
	4	5	N/A
<i>Women's 1</i>	1	-2	0
	2	-1	0
	3	1	5
	4	4	10
<i>Women's 2</i>	1	-1	1
	2	0	3
	3	1	5
	4	1	6
<i>Women's 3</i>	1	-1	1
	2	0	2
	3	0	3
	4	2	10

356

357

**Table 2 Comparison between spatiotemporal characteristics of Open and Women's Polo. Raw values are presented as means  $\pm$  standard deviations, with accompanying p values, effect sizes and C.I. and magnitude descriptors**

Variable	Open	Women's	p value	ES	Confidence Interval	Descriptor
Duration (min:s)	11:54 $\pm$ 02:26	09:09 $\pm$ 01:14	<0.001	1.42	1.14 to 1.69	<i>Large</i>
Distance (m)	3138.89 $\pm$ 491.62	2452.73 $\pm$ 394.27	<0.001	1.54	1.26 to 1.81	<i>Large</i>
Average Speed (km/h)	16.60 $\pm$ 2.35	15.90 $\pm$ 2.41	0.019	0.30	0.05 to 0.54	<i>Small</i>
Average Maximum Speed (km/h)	54.81 $\pm$ 3.55	39.07 $\pm$ 15.66	<0.001	1.39	1.12 to 1.66	<i>Large</i>
Sprints	38.11 $\pm$ 6.80	35.27 $\pm$ 6.86	0.001	0.42	0.17 to 0.66	<i>Small</i>
Impacts	1.72 $\pm$ 1.77	0.72 $\pm$ 1.84	<0.001	0.56	0.30 to 0.80	<i>Small</i>
Accelerations	74.08 $\pm$ 12.94	63.05 $\pm$ 12.94	<0.001	0.85	0.60 to 1.10	<i>Moderate</i>
Decelerations	68.58 $\pm$ 12.02	52.61 $\pm$ 13.55	<0.001	1.25	0.98 to 1.51	<i>Large</i>



## Figure legends

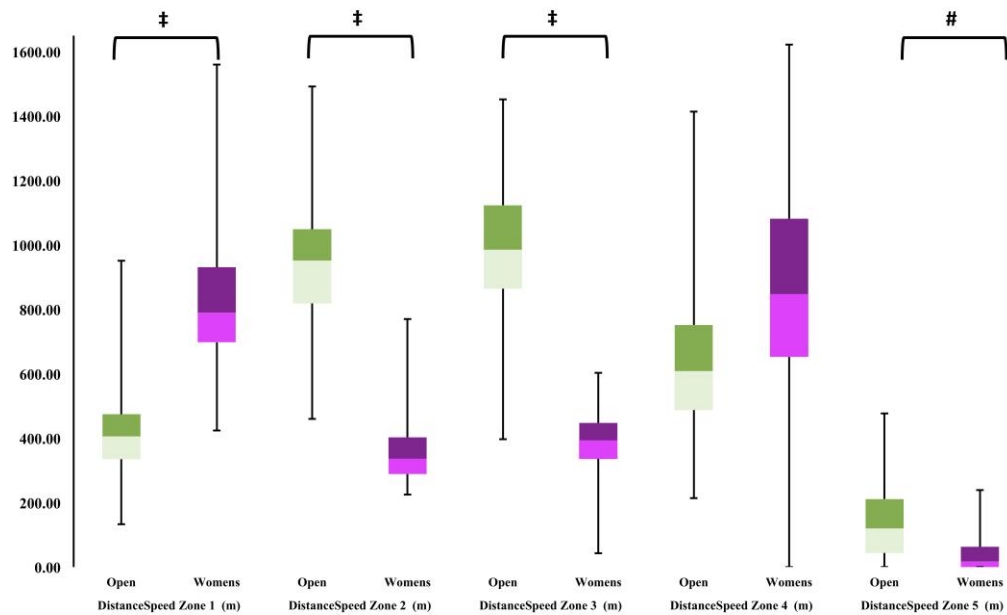


Figure 1: Box and whisker plot showing the distribution of playing speeds (by speed zones) in Open (green boxes) and Women's Polo (purple boxes). Data are presented as medians (change of colour tone) with first and third quartiles; error bars denote minimum and maximum values. Magnitudes of effect sizes are denoted by the following symbols: \*: Small; # Moderate; †: Large; ‡: Very Large.

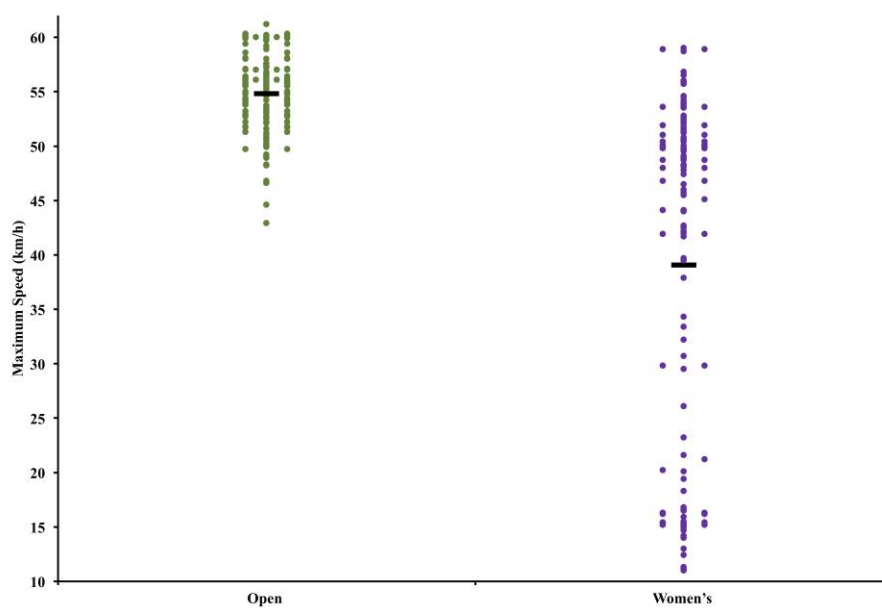


Figure 2: Maximum speeds attained in Open and Women's Polo. Individual data points are represented by open circles and solid black bars represent the mean value for each group.