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

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Summary

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

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

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

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

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Introduction

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

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

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Methods

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

Sample population

This study comprised observations from two distinct playing groups: two open teams and three women's teams – both groups played in the 16-goal sections of their respective tournaments. Open participants consisted of eight Polo players (7 males and 1 female; Handicap range 0–7 goals), whereas women's participants consisted of 12 female Polo players (Handicap range 0–10 goals). Handicaps of individual players are listed in Table 1. Prior to study involvement, informed consent was obtained from players and owners.

Players selected their own strings of ponies, with ponies stabled either truck-side or in open air yards prior to playing. Warm up and feeding protocols were at the players' and grooms' discretion. Playing distribution and strategy of Polo ponies within a player's string was also at the discretion of each player.

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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.
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116 *Statistical Analyses*

117 Data were considered normally distributed if they passed the mean and SD test (2xSD>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

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Results

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

Distance metrics

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

Speed metrics

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

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

High intensity metrics

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

Duration

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

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Discussion

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

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

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

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

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Collectively, these data support the use of a parallel handicap system for Women's Polo due to differences observed in distribution of playing speeds (Fig. 1), typical distances covered per chukka (Table 2) and the greater variability within these characteristics (Fig.1 and 2). These spatiotemporal differences are likely accompanied by differences in technical proficiency and tactical behaviours, evidenced in part by differences in Open handicap (Table 1), which likely contribute to chukka and game outcomes alongside the differences in spatiotemporal characteristics identified in the present study. Concomitant measures of internal load such as horse heart rate would also be of value in assessing the physiological consequences of distances covered per speed zone. It is unclear whether spatiotemporal differences of the present magnitudes signify a genuine need to prepare ponies differently for Open and Women's Polo, or more likely that ponies should be managed differently in games e.g. opting to half chukka ponies in Open Polo.

A possible limitation is that some of these differences may be perceived as occurring simply due to differences in average chukka length. Whilst some influence cannot be ruled out, it is unlikely the sole explanatory factor as the most likely explanation for longer chukkas would either be due to the ball going out of play more frequently, conceding of more penalties by either team or injuries sustained by a player or horse. These incidents all slow down Polo play, therefore fewer metres are accrued in higher speed zones, so the differences between Open and Women's play have occurred in spite of longer chukka lengths in Open Polo. A further limitation of this study is the use of player worn GPS, whilst this is the most feasible strategy for Polo due to multiple horse changes [10], it means braking and turning forces cannot be calculated at the joint and thus our work does not directly support that of Tan and Wilson [19] who calculated the forces experienced by turning Polo ponies. However, due to the high volume of turning and braking movements performed per chukka, and games played per season, we recommend prudent preparation of ponies within a periodised Polo training programme that progressively exposes ponies to the intensities and movement requirements of in-season play.

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

Manufacturers details:

SPSS: (v24, IBM, United States)

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

Supplementary legends:

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

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

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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
Open 1	1	0	N/A
	2	4	10
	3	5	N/A
	4	7	N/A
Open 2	1	2	N/A
	2	3	N/A
	3	6	N/A
	4	5	N/A
Women's 1	1	-2	0
	2	-1	0
	3	1	5
	4	4	10
Women's 2	1	-1	1
	2	0	3
	3	1	5
	4	1	6
Women's 3	1	-1	1
	2	0	2
	3	0	3
	4	2	10

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Table 2 Comparison between spatiotemporal characteristics of Open and Women's Polo. Raw values are presented as means ± 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	±	02:26	09:09	±	01:14	<0.001	1.42	1.14	to	1.69	*Large*
Distance (m)	3138.89	±	491.62	2452.73	±	394.27	<0.001	1.54	1.26	to	1.81	*Large*
Average Speed (km/h)	16.60	±	2.35	15.90	±	2.41	0.019	0.30	0.05	to	0.54	*Small*
Average Maximum Speed (km/h)	54.81	±	3.55	39.07	±	15.66	<0.001	1.39	1.12	to	1.66	*Large*
Sprints	38.11	±	6.80	35.27	±	6.86	0.001	0.42	0.17	to	0.66	*Small*
Impacts	1.72	±	1.77	0.72	±	1.84	<0.001	0.56	0.30	to	0.80	*Small*
Accelerations	74.08	±	12.94	63.05	±	12.94	<0.001	0.85	0.60	to	1.10	*Moderate*
Decelerations	68.58	±	12.02	52.61	±	13.55	<0.001	1.25	0.98	to	1.51	*Large*

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Figure legends

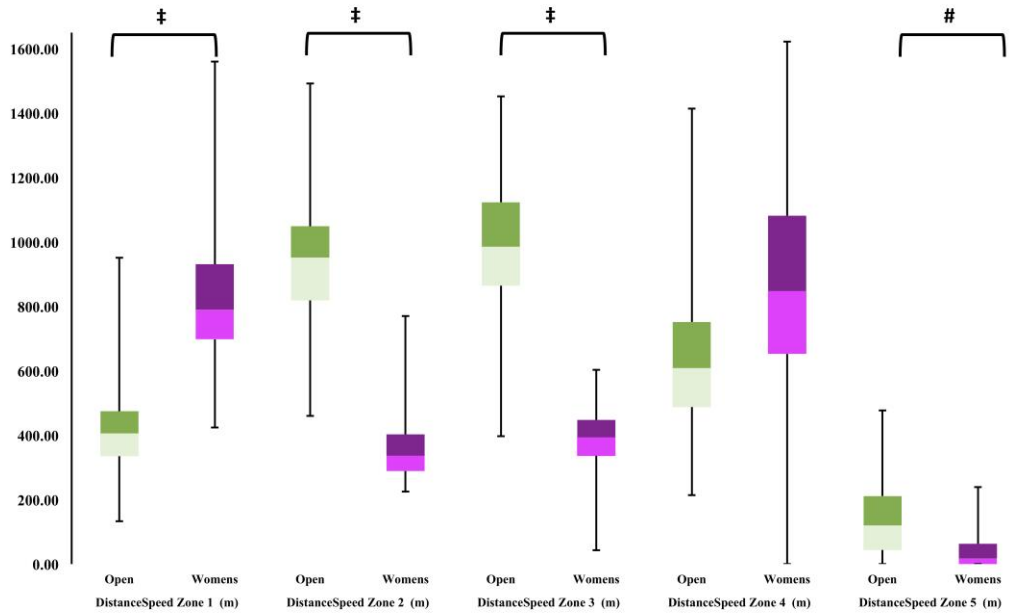

Figure 1: Box and whisker plot showing the distribution of playing speeds (by speed zones) in Open (green boxes) and Women's Polo (purple boxes). Data are presented as medians (change of colour tone) with first and third quartiles; error bars denote minimum and maximum values. Magnitudes of effect sizes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

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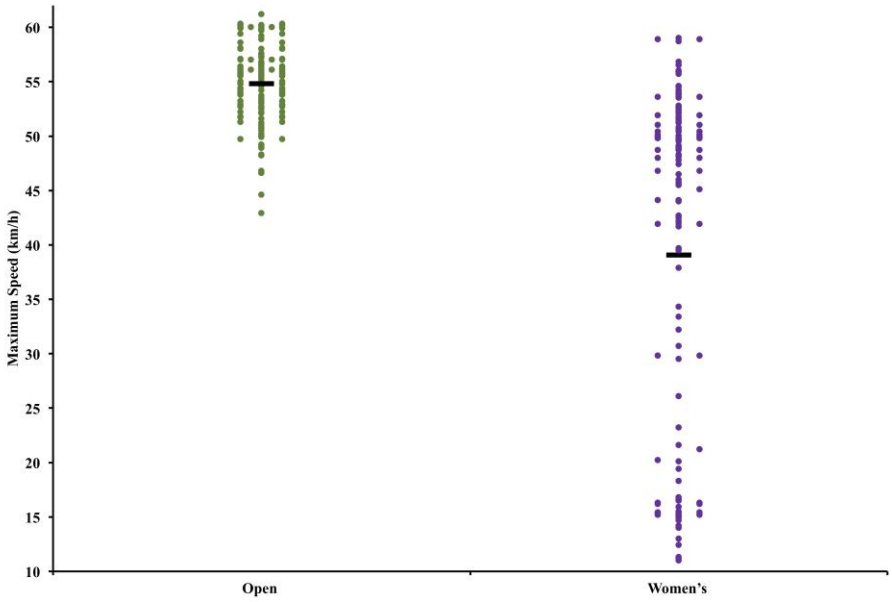

Figure 2: Maximum speeds attained in Open and Women's Polo. Individual data points are represented by open circles and solid black bars represent the mean value for each group.