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All things being equal: spatiotemporal differences between Open and Women's 16-goal Polo

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ABSTRACT

Polo is an equestrian team sport, consisting of Open and Women's only handicapping systems. Equine activities may differ in distribution and their affect upon match outcome in Women's Polo compared to Open Polo, potentially impacting equine preparation and management. We aimed to quantify spatiotemporal differences between Open and Women's Polo when matched for handicap and assess their interaction with chukka and match outcomes. 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. Spatiotemporal metric differences between Open and Women's Polo were *small to large* (ES: 0.54–1.81). In Open Polo, players covered *moderately* more distance in games won (mean: 429.0 m; 95% CI: 238.9 m to 619.0 m), with *small to large* increases in high-intensity activities also performed. Whereas in Women's Polo, *moderately* higher maximum speeds were attained in games won (17.13 km.h⁻¹; 11.86 km.h⁻¹ to 22.40 km.h⁻¹) 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 may influence game outcome differently between codes.

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Polo; equestrian; GPS; horse welfare; horse management

1. 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 (Fiander & Williams, 2014; Hurlingham Polo Association, 2018; Williams & Fiander, 2014). Individual handicaps are awarded from -2 to +10 goals, with level of play dictated by the cumulative handicap of each member of a team (Hurlingham Polo Association, 2018). Initiated by Argentina in 2010 (Laffaye, 2014), a women's handicapping system is now implemented by most Polo playing nations, with a view to increasing participation and the quality of women's Polo internationally (Oliver, Gilmer, Barfield, & Brittain, 2019) and is usually higher than an equivalent open handicap (Hurlingham Polo Association, 2019).

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 Supplemental data for this article can be accessed [here](#).

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Previously, we have shown increases in average speed attained and distance covered per chukka (Best & Standing, 2019c) as cumulative handicap increases in Open Polo; cumulative handicap may also affect high-intensity activities (Best & Standing, 2019c), imposing additional internal physiological loads upon horses and players (Best & Standing, 2019b; Gondin et al., 2013; Marlin & Allen, 1999; Wright & Peters, 2017; Zobba et al., 2011). 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 assess 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.

2. 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 and were considered appropriate for the tournament being played. 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 (Best & Standing, 2019a) [dataset].

2.1. 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), whereas women's participants consisted of 12 female Polo players. Handicaps of individual players are listed in Table 1. Prior to study involvement, informed consent was obtained from players/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 players' and discretion. All horses were in playing condition. Playing distribution and strategy of Polo ponies within a player's string was also at the discretion of each player.

2.2. Data collection procedures

Data were collected from a total of 258 chukkas across both Open and Women's Polo tournaments ($n = 130$ and $n = 128$, respectively) using player worn GPS monitors (VX Sport 350, VX Sport, Lower Hutt, New Zealand), set to equestrian mode with a sampling frequency of 10 Hz and a speed range of 0–60 km.h⁻¹. We have previously shown this method to produce reliable results for values of distances covered per speed zone (m),

Table 1. Player handicaps (goals) for each playing gender, where appropriate.

| 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 |

time in speed zone (min:s), accelerations, decelerations and sprints (Best & Standing, 2019b), when mounted either between the players' shoulders or worn on players' belts. Reported coefficients of variation ranged from 1.1% to 9.1% and intra-class correlation coefficients of 0.97–1.00 and so were deemed qualitatively reliable, as per previously recommended thresholds for coefficients of variation <10% and intra-class correlation coefficients >0.70 (Best & Standing, 2019b; Standing & Maulder, 2017).

GPS units were turned upon arrival at the playing venues to obtain an initial satellite lock and were then turned on again 30 min prior to the start of games, to ensure a secure connection to multiple satellites was established. All players opted to wear GPS units in a pouch fixed to their belts. The belt pouch was secured with insulation tape to minimise oscillation of the unit during games. Upon game completion, units were turned off and data downloaded using specialist software as provided by the manufacturer (VX Sport, Upper Hutt, New Zealand). The initial satellite lock period was trimmed from the data, and the game period was divided into chukkas as per an accompanying notational analysis to normalise data for between and within groups analyses. Speed zones using in-built software thresholds were derived as follows: Zone 1: 0–19.2 km.h⁻¹; Zone 2: 19.2–23.4 km.h⁻¹; Zone 3: 23.4–28.2 km.h⁻¹; Zone 4: 28.2–47.4 km.h⁻¹; and Zone 5: 47.4–60 km.h⁻¹; corresponding with equine gaits of walk/trot, canter, fast canter – gallop, gallop and maximal effort (Rogers & Firth, 2004). These transitions are approximate, however, as horse gaits tend to be categorised via foot fall sequences as opposed to velocity (Robilliard, Pfau, & Wilson, 2007; Rogers & Firth, 2004); furthermore, players and horses may perform Polo specific activities whilst still maintaining their velocity, and thus remain within a speed zone, but gait would not be able to be discretely categorised. Total distance (m), distance covered (m) in each speed zone, the number of accelerations, decelerations, impacts and sprints (an acceleration >3 m.s⁻²) were selected as dependent variables from the GPS output, with chukka duration (min:s) reported from the notational analysis. Data were then exported to Microsoft Excel for further analysis as detailed below. Players were provided with a brief data analysis and feedback per chukka the day after each game.

2.3. Statistical analyses

Data were considered normally distributed if the Shapiro-Wilks statistic was $p > 0.05$, if skewness and kurtosis were within ± 1 , if the mean and median were within 10% of each other, or if $2xSD > \text{mean}$ (Bradshaw, Maulder, & Keogh, 2007; Peat & Barton, 2005). Following these tests, between group differences were analysed using an independent samples t-test with alpha defined *a priori* as $p < 0.05$. A two factor mixed effects ANOVA was used to assess the interaction between spatiotemporal characteristics and chukka (win/loss) and game outcomes (win/loss), at the same alpha level. Specifically, chukka and game outcomes were considered fixed factors due to their being categorical variables and binary in nature, and spatiotemporal characteristics classed as dependent variables, due to their continuous nature. Similar analyses have been performed in other team sports (Douglas et al., 2019; Vigne et al., 2013). It should be noted that the absence of statistical significance does not signify lack of practical importance to Polo performance. All analytical procedures were computed using SPSS (v24, IBM, United States). Effect sizes for between group comparisons (Cohen's d) and accompanying 95% confidence intervals (C.I.) were calculated using a customised spreadsheet. Magnitudes of effect were interpreted using the descriptors suggested by Hopkins et al. (Hopkins, Marshall, Batterham, & Hanin, 2009): *Trivial* 0.0–0.2; *Small* 0.2–0.6; *Moderate* 0.6–1.2; *Large* 1.2–2.0 and *Very Large* > 2.0 . An effect was deemed *unclear* if its confidence interval crossed zero and the threshold for a *small* effect (Batterham & Hopkins, 2006). For within group comparisons (chukka and game win-loss outcomes) data are reported as raw differences between outcomes with accompanying 95% confidence intervals, effect sizes (Cohen's d) and magnitude-based descriptors.

3. Results

Significant differences between Open and Women's Polo were found for all spatiotemporal characteristics assessed (all $p < 0.05$), although these differences varied in terms of magnitude (*Small* to *Very Large*); these differences are 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.

3.1. 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.

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 |
|------------------------------|---------|--------|---------|--------|---------|------|---------------------|---------|------------|
| | Mean | SD | Mean | SD | | | Lower | Upper | |
| 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 |

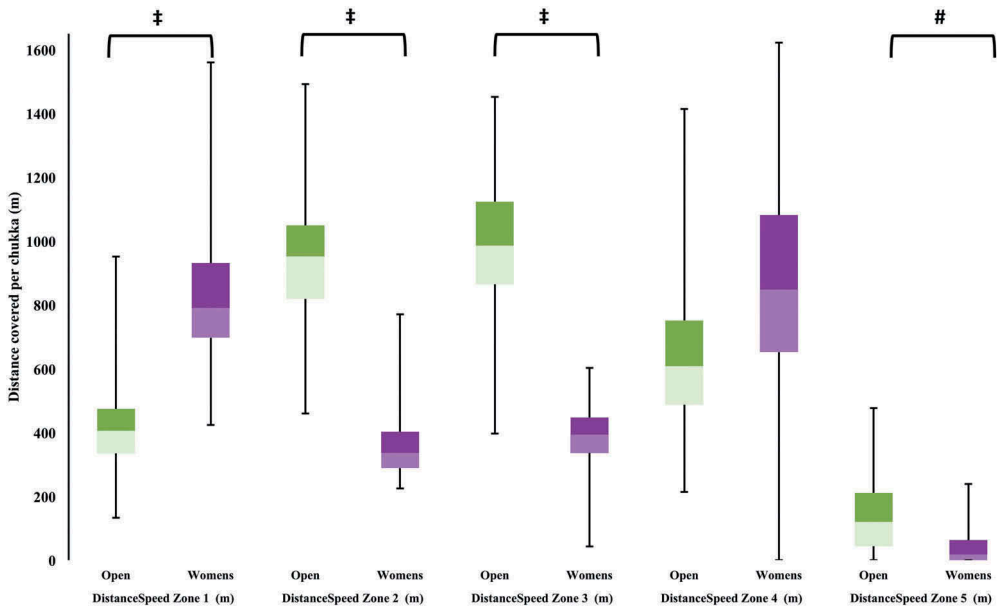


Figure 1. Box and whisker plot showing the distribution of playing speeds (by speed zones) in Open (green boxes) and Women's Polo (purple boxes). Data are presented as medians (change of colour tone) with first and third quartiles; error bars denote minimum and maximum values. Magnitudes of effect sizes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

3.2. Distance metrics

Between groups differences for 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 (-231.2 m; -421.3 m to -41.2 m) but *moderately* more distance covered in games won (429.0 m; 238.9 m to 619.0 m). 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 ($F(1,124) = 2.01$; $p = 0.017$).

3.3. Speed metrics

Average and maximum speeds behaved differently between groups; a *small* reduction in average speed (-1.37 km.h^{-1} ; -2.33 km.h^{-1} to -0.40 km.h^{-1}) 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^{-1} ; 11.86 km.h^{-1} to 22.40 km.h^{-1} ; $F(1,124) = 41.40$; $p < 0.001$). Absolute maximum speeds for Open and Women's play were 61.5 and 59 km.h^{-1} respectively, with *large* differences in average maximum speeds ($p < 0.001$, Table 2) between groups but only *small* differences in average playing speed ($p = 0.019$; Table 2). Additionally, all maximum speed data for each category of play are shown in Figure 2 to demonstrate the distribution of maximal speeds between groups.

3.4. 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) was

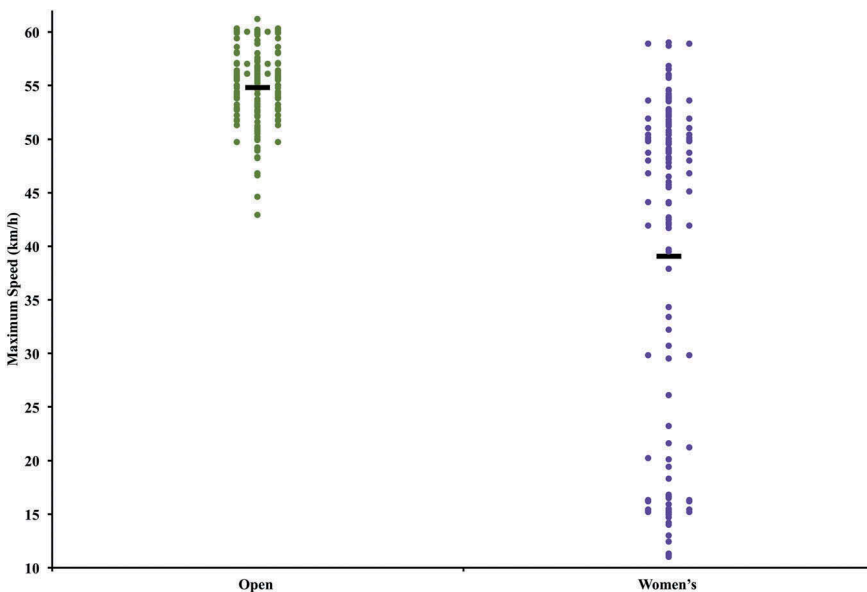


Figure 2. Maximum speeds attained in Open and Women's Polo. Individual data points are represented by open circles and solid black bars represent the mean value for each group.

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*.

4. Discussion

We 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*. Differences in spatiotemporal characteristics have previously been shown to differentiate between levels of Polo (0–24 goals; Best & Standing, 2019c) and between playing positions in Polocrosse (Yarnell, Starbuck, Riley, & Woodhead, 2019), with greater distances covered as handicap increases (Best & Standing, 2019c), and by defenders, respectively (Yarnell et al., 2019). Understanding positional demands would further advance the present work, but a direct comparison to Polocrosse cannot be made as Polo involves fewer players, more ponies and a very different playing pattern (chukka duration and recovery between chukkas).

The differences in distance between Open and Woman's Polo are further emphasised by Figure 1. Women's Polo displays a U-like distribution with broad error bars especially in speed zone 4, 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 ins (i.e. greater rates of acceleration) and serve a different tactical purpose in comparison to Women's Polo. Speed shows a more polarised distribution of a seemingly stochastic nature in Women's Polo; accompanying error margins highlight that whilst players may be physically and technically proficient (Standing & Best, 2019), 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 (Best & Standing, 2019a; Birch, Wilson, & Goodship, 2008; Eto et al., 2004), although this has been noted to be potentially injurious in thoroughbreds (Birch et al., 2008). Injury may also occur in horses if the relationship between speed and limb force exceeds a critical limit during turns (Tan & Wilson, 2010) but Polo ponies typically display a greater tolerance to this and can turn in tighter circles than race horses (Tan & Wilson, 2010). Irrespective of the source, injury risk must be minimised by appropriate loading of ponies (Carrier et al., 1998; Castejon-Riber, Riber, Rubio, Agüera, & Muñoz, 2017) 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). Whilst Figure 2 clearly indicates higher speeds are attained more frequently in Open Polo, this is not to suggest that high maximum speeds are not of practical (equine fitness) or tactical (game outcome) importance in Women's Polo, indeed maximal speed differed by 17.13 km.h-1

(11.86 km.h⁻¹ to 22.40 km.h⁻¹) in games won. 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 (Carrier et al., 1998; Castejon-Riber et al., 2017). 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 pony's lower limb, with tendon injuries frequently reported in Polo (Best & Standing, 2019c; Inness & Morgan, 2015). Such injury is likely due to repetitive eccentric loading across multiple joints (Butler, Valenchon, Annan, Whay, & Mullan, 2019) brought about by simultaneous braking and turning forces (Brocklehurst, Weller, & Pfau, 2014; Chateau et al., 2013), attention should also be paid to the speed at which these movements are trained (Tan & Wilson, 2010) to minimise injury risk, regardless of code of Polo played.

Collectively, these data support the use of a separate handicap for Women's Polo due to differences in the distribution of playing speeds, typical distances covered per chukka and the greater variability within these characteristics. These spatiotemporal differences are likely accompanied and in some cases driven by differences in technical proficiency and tactical behaviours, evidenced in part by differences in Open handicap (Table 1), which may be more causative and of greater practical importance to chukka and game outcomes than 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, more likely that ponies should be managed differently in games, e.g. opting to half chukka ponies in Open Polo. Such management may extend to the duration of a tournament, depending upon the age and playing experience of ponies. These data also emphasise the need for greater transparency and parity within both Open and Women's handicapping criteria, especially for female players who may play across both codes.

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 pony. These incidents all promote a slowing of play and therefore metres accrued in higher speed zones, so the differences between Open and Women's play have in fact 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 (Best & Standing, 2019b), 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 (Tan & Wilson, 2010) 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 respective handicaps, present with *small to large* spatiotemporal differences that may be of practical as well as statistical significance. Within Polo codes, a greater number of variables were affected by game and chukka outcome in Open Polo, and there was limited commonality between groups as to variables that were associated with 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 and 3000 m 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.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Data accessibility

An anonymised dataset used in this study can be found online at: <https://doi.org/10.3390/data4030095>

Ethical statement

This research was carried out with owner informed consent in accordance with ethical animal research guidelines (International Guiding Principles for Biomedical Research Involving Animals), and was approved by WINTEC ethics committee (Approval code: WTFE2601102018).

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