Article

Strength and Reaction Time Capabilities of New Zealand Polo Players and Their Association with Polo Playing Handicap

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Abstract: Polo is an equestrian team sport consisting of four players per team, with level of play determined by cumulative player handicap (-2 to + 10 goals), with a higher handicap denoting a better player. There is minimal literature investigating Polo players' physical attributes, hence the understanding of the physical characteristics that may contribute to an improved handicap are unknown. This study sought to identify the relationship between pertinent strength measures (left and right hand grip strength; absolute and relative isometric mid-thigh pull) and reaction time in Polo handicap in 19 New Zealand Polo players, and ascertain whether handicap could be predicted by these measures. Correlation coefficients were expressed using R values, accompanying descriptors and 90% confidence intervals (C.I.). Variance explained was expressed via the R^2 statistic, and statistical significance set at $p < 0.05$. Right hand grip strength, isometric mid-thigh pull values were found to significantly correlate to and explain variance within Polo player handicap (all *moderate* to *large* correlations; $p < 0.05$). Whereas left hand grip strength (R: 0.380; 90% C.I. -0.011 to 0.670) and reaction time (0.020; -0.372 to 0.406) were non-significant, *moderate* and *trivial* correlates and predictors of handicap respectively. Practically, these findings highlight the differing roles between rein and mallet hands of Polo players and emphasise the importance of a strong and stable platform when riding and striking the ball. Lack of association with reaction time may be explained in part by higher handicapped Polo players employing a more proactive approach to the game.

Keywords: grip strength; reaction time; isometric strength; Polo; equestrian

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1. Introduction

Polo is one of the oldest equestrian sports in the world and requires the synchronisation of both equine and human athletes in a dynamic and high-paced environment [1]. Previous literature has begun to characterise Polo gameplay through global positioning systems (GPS) [2], quantitative performance analysis [3], and equine internal workloads via heart rate [4,5], and biochemical responses [6]. These investigations have allowed insight into the science behind Polo and discuss how applied research may be utilised within the sport. One factor each of these previous studies has acknowledged, is the subjective handicap rating system used to provide Polo players a quantitative measure of their ability (between –2 and +10) [7]. This system is based on a variety of features including horsemanship, playing skills, technique and the quality of horses being utilised [7]. Many of these factors contributing to handicap rely on the physical capabilities of the players themselves. Horse riding requires physical strength through both the upper and lower limbs, general cardiovascular endurance, balance, reaction time and flexibility [8,9], with these elements further complicated by the grips, sudden accelerations / decelerations, and reaction times required when the dynamic and unpredictable demands of Polo gameplay are introduced. The need to identify, train, and evaluate the physical attributes required for effective and safe Polo performance is crucial [10], as players may be exposed to speeds exceeding 60km/h and distances upwards of 5km per chukka [1,11] which potentiates a variety of risks and potential for injury [1].

The aim of this study is to quantify the sport-specific physical characteristics of Polo players, and furthermore, to assess the relationship these characteristics have to player handicap. Findings will provide evidence to inform Polo athlete training programmes and also advise how physical attributes may contribute to improving player handicap. It is hypothesised that left and right grip strength, and lower limb strength, will possess high correlations to player handicap. This is due to the large forces required to manipulate a horse at high speeds and control the mallet through high velocity contacts. It is also hypothesised that reaction time will show little correlation to handicap, as a proactive tactical awareness becomes better developed as experience in the sport increases.

2. Materials and Methods

Experimental approach

Player handicap was selected as the independent variable, as this is a measure of players' Polo ability that is awarded by the local Polo governing body (e.g. the New Zealand Polo Association) and reviewed annually; therefore, it could not be manipulated by the researchers. The dependent variables of interest were selected as strength assessments related to horse riding skill or body position (hand grip; isometric mid-thigh pull (IMTP)) and mimicked the dynamic requirements of Polo (reaction time) [8,9].

Subjects

Nineteen participants (12 male; 7 female) were originally recruited for this investigation (Handicap: 0 ± 2 goals; Age: 36.2 ± 14.1y; Weight: 78.9 ± 19.4kg). Participants' height was not recorded due to the variability in heel height of players' Polo boots; it would have been unsafe for testing to be performed unshod. Ethical approval for this investigation was awarded by the institution's Human Ethics Research Group. Participants provided written informed consent prior to undertaking the testing battery and retained the right to withdraw themselves and their data from the study at any time.

Procedures

Left and right-hand grip strength was assessed via a hand grip dynamometer (Smedlay's, Tokyo), calibrated up to 100kg. Grip strength procedures need to mimic the specific demands of the sport to improve the validity of the recording [12]. As such, participants were asked to grip the dynamometer firmly and raise their hand above their head with the palm facing forward. They were to then squeeze as hard as possible and adduct the shoulder whilst pronating the forearm. The final position was with their arm by their side with the palm facing medially. This protocol was used as it best mimics the dynamics of a Polo swing. Participants self-selected their starting hand but alternated between trials.

Isometric mid-thigh pull (IMTP) was assessed using a customised testing rig, consisting of two Pasco force plates (Roseville, California) and perpendicular vertical poles drilled at 1cm increments to allow appropriate grip adjustment and positioning of the bar to the participants' mid-thigh. Similar protocols have shown reliable measures both within (ICC = 0.97) and between (ICC = 0.89) sessions [13]. Peak IMTP net forces were recorded in Newtons (N), and Newtons per kilogram (N/kg) for relative forces.

Reaction time was assessed via Fitlight reaction lights (Ontario, Canada) set at 30sec sample duration, with a 0.1 sec delay between lights. The number of lights a participant correctly waved their hands over in a 30 sec period was recorded. Lights were mounted on two tables positioned in a right angle and arranged in a fan-like shape around the participant; lights were not placed behind the participants as when mounted on a horse a player cannot leave the confines of the saddle, and to play behind the saddle is considered dangerous.

Participants were permitted three attempts for each test following a demonstration by a researcher, participants' best efforts were used for analysis.

Statistical Analyses

Data were assessed for normality via the Shapiro Wilks test and found to be normally distributed (p>0.05), meaning parametric tests could be employed. Pearson correlation coefficients were used to assess the relationship between Polo handicap and measures of strength and reaction time, with statistical significance set *a priori* at $p \leq 0.05$. Ninety percent confidence intervals (C.I.) are used to describe the uncertainty in the data and magnitudes of relationships were described using the following intervals: *Trivial* 0 – 0.2, *Small* 0.1 – 0.3, *Moderate* 0.3 – 0.5, *Large* 0.5 – 0.7, *Very Large* 0.7 – 0.9 and *Nearly Perfect* >0.9 [14]. Variance explained was expressed via the R^2 statistic.

Linear regression was used to determine the predictive ability of Polo handicap upon strength variables and reaction time, with relationships described using the formula $y = a + bx$; where y is the dependent variable score, a is the intercept on the y axis, b is the slope of the regression line and x is the Polo handicap. For clarity, correlation coefficients, p values, and R^2 values are stated to three decimal places. All data analysis was conducted in SPSS (IBM SPSS Statistics version 24, IBM, location); confidence intervals for correlation coefficients were calculated using a customised spreadsheet [15].

3. Results

Group means identified handgrip strength was greater in the right hand (50.9kg ± 16.6) when compared to the left (46.3kg ± 15). As depicted in Table 1, both left and right handgrip strengths displayed Moderate to Large correlations to player handicap, with significance achieved by the right hand only ($p = 0.019$). Significant relationships to player handicap were also demonstrated by IMTP ($p = 0.004$) and IMTP-R ($p = 0.035$), which displayed correlations to player handicap of 0.609 and 0.484, respectively. Reaction time was shown to have a non-significant relationship ($p = 0.889$) to player handicap, with a group mean of 23.3 ± 2.7.

All variables that displayed significant relationships to handicap (right handgrip strength, IMTP and IMTP-R) also demonstrated significant R^2 values, suggesting that these metrics may be predictive of Polo handicap. Regression equations for each variable can be found in Table 1; individual data plots for each variable that displayed moderate to large relationships with player handicap, with accompanying regression lines are depicted in Figure 1, panels A-D.

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3.2.

Table 1: Correlation coefficients between Polo handicap and strength and reaction time (RT). Accompanying 90% Confidence intervals (C.I.), *p* values and magnitude descriptors are also shown. Variance explained (R^2) and the linear regression equations are also presented for each variable, as per Polo handicap. HG: Handgrip; IMTP: Isometric mid-thigh pull; IMTP-R: Isometric mid-thigh pull relative to bodyweight; RT: Reaction time: Significant values (p<0.05) are denoted by an asterisk *.

Variable	**Correlation**	**90% C.I.**	***p* value**	**Descriptor**	**R^2 value**	**Regression equation**
HG Left	0.380	-0.011 to 0.670	0.102	*Moderate*	0.144	y=2.387x + 44.362
HG Right	0.523	0.168 to 0.758	0.019*	*Large*	0.274*	y=3.613x + 48.305
IMTP	0.609	0.275 to 0.812	0.004*	*Large*	0.371*	y=148.030x + 1766.396
IMTP-R	0.484	0.103 to 0.741	0.035*	*Moderate*	0.235*	y=1.065x + 23.258
RT	0.020	-0.372 to 0.406	0.889	*Trivial*	0.001	y=-0.037x + 23.463

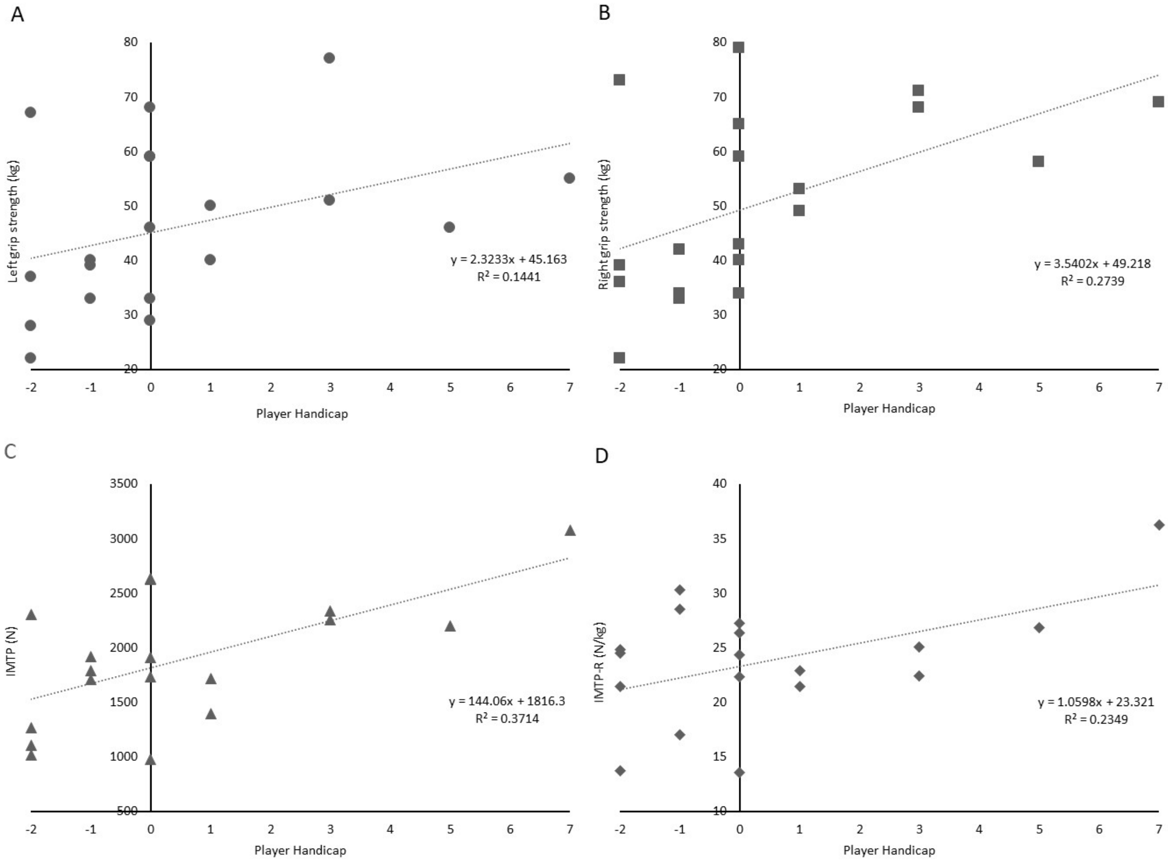

Figure 1. Individual data points and accompanying linear regression lines for left (Panel A) and right (Panel B) hand grip strength, IMTP (Panel C) and IMTP-R (Panel D).

4. Discussion

The purpose of this study was to characterise strength and reaction time attributes of Polo players and assess the relationship between these factors and player handicap. This study shows that right-hand grip strength, IMTP, and IMTP-R have significant relationships to player handicap. However, reaction time neither correlates to nor is predictive of player handicap, therefore supporting the hypothesis of this paper. Left-hand grip strength presented a non-significant *moderate* relationship with player handicap, which was contrary to the initial hypothesis.

The ability to grip and manipulate objects is an important aspect of many sporting endeavours, with athletes often requiring a combination of general grip strength and the ability to produce intricate movements to perform most effectively [16]. A range of handgrip strength values are present across sporting codes [12], with dressage horse riders displaying some of the lowest hand grip values (<30kg) [17] and rowers displaying some of the highest (>70kg) [18]. In the current study, handgrip strength was higher than previous equine-based investigations [11,17,19], although the methods of collecting handgrip strength differed based on the event specific requirements of the various equestrian pursuits examined. Differences in methodology have also been shown to influence the validity of maximal measures in some instances and therefore may account for some of the variation identified [12]. It is suggested that handgrip demands differ between equestrian events, and with the added intensity, speed and manoeuvrability required in Polo, a stronger grip may in fact be more advantageous. With the added need to manipulate the mallet with the right-hand, strength becomes important to repeatedly control impacts on the ball and produce consistent shots. Weaker correlations and decreased grip strength were observed in the left hand. This may be explained by the riding style required for Polo (K. Brooks & J.P. Clarkin, personal communication, March 24, 2019), where finesse and intricate controlled movements are used to manoeuvre the horse via the left-hand on the reins, and not necessarily through strong and forceful movements as initially hypothesised. The left to right asymmetry may also be described by the right-hand dominance which is witnessed in 80-90% of demographic studies [12,20,21]. Whilst using one hand to swing the mallet, and the other to manipulate the horse, the need to remain stable in the saddle is also of critical importance.

Stability in the saddle is determined by the interaction of various factors, namely the horse, type of saddle, rider and the type of movements being performed [22]. Stability is maintained by the rider's ability to follow the movements of the horse and by using both legs to provide the base for this movement [22,23]. IMTP-R and IMTP displayed *moderate* to *large* relationships with player handicap and significant R^2 values of 0.235 and 0.371, respectively, highlighting the predictive qualities of these measures. There is a clear need for a strong base of support and the ability to produce high levels of force on the stirrups, through both legs whilst Polo players are riding at speed, playing shots out of their saddle and absorbing contacts from different angles (ride-off). Previous literature has performed static muscle testing of the lower limb [24], with no significant differences between riders and control groups identified. There is a paucity of literature surrounding lower limb strength in horse riders, therefore the novel findings of this relationship warrant further investigation within a Polo context to better understand how this can be assessed dynamically, to mirror the oscillatory pattern of riding.

The ability to predict gameplay and be proactive in sport is a skill that comes with experience and knowledge of the game [25,26]. Polo is no exception to this rule, as reaction time was shown to have a *trivial* non-significant relationship to handicap. The need to be proactive and predict plays is a skill that does not necessarily require fast reaction times, rather an ability to read the game and respond more efficiently. Through time in the saddle, players gain valuable insight into how the game is played which allows them to make better-informed decisions about when and where they need to be on the pitch, and how to manipulate their horses to accomplish this effectively. These skills are contributors to 'horsemanship' and 'playing skills', two of the categories considered when player handicap is attributed [7]. It is important to note, that the physical characteristics measured within this study are not directly measured to influence or attain player handicap ratings. These variables do however contribute to the players ability to perform the subjectively measured aspects related to Polo play.

Practical applications

Without consistent and objective handicap profiling procedures, it is difficult to make conclusive statements about how players may be able to utilise these findings to improve their handicap. However, results of this study suggest practitioners working with Polo players, or other equestrian pursuits, should focus on the development of grip strength, as well as the riders' ability to stabilise and transfer force through their lower limb as this provides a stronger platform on the stirrup when playing on-ball. Time spent developing players' ability to read the game and make proactive moves may be a more effective use of time than training reactive components. Future research should further investigate the bilateral differences between left and right hands of Polo players, and the motor nuance required to perform most effectively. Lower limb strength and endurance capacities should also be investigated within Polo and could be used in conjunction with player heart rates to clarify central or peripheral limitations [27]. Further information pertaining to the internal physical demands and external workloads of Polo would further aid in training programmes for Polo players.

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References

1. Costa-Paz, M.; Aponte-Tinao, L.; Muscolo, D.L. Injuries to polo riders: a prospective evaluation. *Br. J. Sports Med.* **2008**, *33*, 329–331.
2. Best, R.; Standing, R. Feasibility of a Global Positioning System to assess the spatiotemporal characteristics of Polo performance. *J. Equine Vet. Sci.* **2019**.
3. Best, R.; Standing, R. Performance Characteristics of a Winning Polo Team. *New Zeal. J. Sport Exerc. Sci.* **2019**, *2*, 1–11.
4. Marlin, D.J.; Allen, J.C.R. Cardiovascular demands of competition on low-goal (non-elite) polo ponies. *Equine Vet. J.* **1999**.
5. Wright, R.; Peters, D. A heart rate analysis of the cardiovascular demands of elite level competitive polo. *Int. J. Perform. Anal. Sport* **2008**, *8*, 76–81.
6. Zobba, R.; Ardu, M.; Niccolini, S.; Cubeddu, F.; Dimauro, C.; Bonelli, P.; Dedola, C.; Visco, S.; Pinna Parpaglia, M.L. Physical, Hematological, and Biochemical Responses to Acute Intense Exercise in Polo Horses. *J. Equine Vet. Sci.* **2011**, *31*, 542–548.
7. Hurlingham Polo Association *Outdoor Rules and Regulations*; Hurlingham Polo Association: Faringdon, 2018;
8. Mitani, Y.; Doi, K.; Yano, T.; Sakamaki, E.; Mukai, K.; Shinomiya, Y.; Kimura, T. Effect of Exercise Using a Horse-Riding Simulator on Physical Ability of Frail Seniors. *J. Phys. Ther. Sci.* **2008**, *20*, 177–183.
9. Hitchens, P.; Blizzard, L.; Jones, G.; Day, L.; Fell, J. Are physiological attributes of jockeys predictors of falls? a pilot study. *BMJ Open* **2014**, *1*, 1–7.
10. Noleto, P.G.; Cubas, J.P.C.; Barbosa, F.C.; Guimarães, E.C.; Mundim, A. V. Biochemical profile of polo horses in training phase and those players of official competition: Biochemical profile of polo horses. *Comp. Clin. Path.* **2016**, *25*, 911–915.
11. Warrington, G.; Dolan, E.; McGoldrick, A.; McEvoy, J.; MacManus, C.; Griffin, M.; Lyons, D. Chronic weight control impacts on physiological function and bone health in elite jockeys. *J. Sports Sci.* **2009**, *27*, 543–550.
12. Cronin, J.; Lawton, T.; Harris, N.; Kilding, A.; McMaster, D.T. A brief review of handgrip strength and sport performance. *J. Strength Cond. Res.* **2017**, *31*, 3187–3217.
13. De Witt, J.K.; English, K.L.; Crowell, J.B.; Kalogera, K.L.; Guilliams, M.E.; Nieschwitz, B.E.; Hanson, A.M.; Ploutz-Snyder, L.L. Isometric Midthigh Pull Reliability and Relationship to Deadlift One Repetition Maximum. *J. strength Cond. Res.* **2018**, *32*, 528–533.
14. Hopkins, W.G.; Marshall, S.W.; Batterham, A.M.; Hanin, J. Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.* **2009**.
15. Hopkins, W.G. A spreadsheet for deriving a confidence interval, mechanistic inference and clinical inference from a p value. *Sportscience* **2007**, *11*, 16–20.
16. Moran, C.A. Anatomy of the hand. *Phys. Ther.* **1989**, *69*, 1007–1013.
17. Hobbs, S.J.; Baxter, J.; Broom, L.; Rossell, L.-A.; Sinclair, J.; Clayton, H.M. Posture, Flexibility and Grip Strength in Horse Riders. *J. Hum. Kinet.* **2014**, *42*, 113–125.
18. Secher, N.H. Isometric rowing strength of experienced and inexperienced oarsmen. *Med. Sci. Sports Exerc.* **1975**, *7*, 280–283.
19. Meyers, M.C. Effect of equitation training on health and physical fitness of college females. *Eur. J. Appl. Physiol.* **2006**, *98*, 177–184.
20. Johnston, D.W.; Nicholls, M.E.R.; Shah, M.; Shields, M.A. Nature's experiment? Handedness and early childhood development. *Demography* **2009**, *46*, 281–301.
21. Llaurens, V.; Raymond, M.; Faurie, C. Why are some people left-handed? An evolutionary perspective. *Biol. Sci.* 2009.
22. Peham, C.; Kotschwar, A.B.; Borkenhagen, B.; Kuhnke, S.; Molsner, J.; Baltacis, A. A comparison of forces acting on the horse's back and the stability of the rider's seat in different positions at the trot. *Vet. J.* **2010**, *184*, 56–59.
23. Greve, L.; Dyson, S. The horse-saddle-rider interaction. *Vet. J.* **2013**, *195*, 275–281.
24. Westerling, D. Applied Physiology A Study of Physical Demands in Riding. *Scand. J. Clin. Lab. Investig.* **1983**, *50*, 373–382.
25. Aglioti, S.M.; Cesari, P.; Romani, M.; Urgesi, C. Action anticipation and motor resonance in elite basketball players. *Nat. Neurosci.* **2008**, *11*, 1109–1116.
26. Cañal-Bruland, R.; Schmidt, M. Response bias in judging deceptive movements. *Acta Psychol. (Amst).* **2009**, *130*, 235–240.
27. Mclaren, S.J.; Graham, M.; Spears, I.R.; Weston, M. The sensitivity of differential ratings of perceived exertion as measures of internal load. *Int. J. Sports Physiol. Perform.* **2016**