Chapter 5.2 – PHYSIOLOGICAL BASIS FOR HOME ADVANTAGE

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Summary

The physiological basis for a *home advantage* has received little attention with investigations predominantly focussing on endocrine responses including fluctuations in innate cortisol and testosterone. However, this endocrine effect has been variably observed with its association with performance and success inconsistent, possibly due to psycho-physiological interactions. The physiological effects of environmental acclimation and travel fatigue may also indirectly contribute to a *home advantage* that requires further investigation. While the existence of a *home advantage* has been purported, the current evidence for a physiological basis is tentative with future work needed to clearly confirm the physiological mechanisms.

Introduction

Athletes compete within a range of contexts with success reported to be influenced by competition/match location, i.e. *home advantage* (Chapter 1). For some years, there has been interest in the existence of a *home advantage* (Pollard, 1986) with this evident at the elite and international sporting level (Balmer et al., 2001; Wilson & Ramchandani, 2017). Studies to date have focussed on a range of possible contributors to the *home advantage* such as sociological (Chapter 4), psychological (Chapter 5.1) and officiating (Chapter 7) factors. However, competing at home has also been proposed to bring about significant physiological responses that lead to enhanced performance and success (Carre et al., 2006; Pollard, 1986). The evidence for a physiological basis for the *home advantage* though has been scant with variable results. The most common physiological mechanism proposed has been endocrine based while others (e.g. environmental, travel) have also been proposed.

Endocrine/hormonal mechanisms

Animal studies have shown that 'defending one's home' is instinctive with the introduction of visitors leading to increased aggression, attacks and death of visitors (Fuxjager et al., 2010; Thor & Flannelly, 1976). This aggressive behaviour was greater with older animals who exhibited elevated testosterone levels (Thor & Flannelly, 1976). Subsequently, increased testosterone levels at home were suggested to promote this greater aggression and territorial behaviour (Thor & Flannelly, 1976), contributing to a *home advantage*. Within elite sport, soccer, rugby union and ice hockey athletes were reported to experience greater testosterone levels prior to home matches compared to away matches (Carre et al., 2006; Cunniffe et al., 2015; Neave & Wolfson, 2003). Testosterone levels were also positively associated with the degree of rivalry between competing teams supporting the link between testosterone and aggression (Neave & Wolfson, 2003). Further, elite judo athletes were reported to attack and score more frequently when competing at home (Brito et al., 2017). In comparison, visiting judo athletes hesitated more during competition, exemplary of less aggressive behaviour (Brito et al., 2017). Finally, aggressive behaviour of athletes was associated with the greater *home advantage* (67%) identified for professional rugby teams compared to other sports in Spain over a 5-year period (Gómez et al., 2011). Collectively, these studies implied that competing at home may lead to an acute increase in testosterone levels and subsequent aggressive behaviour for a *home advantage*. Further, this aggressive behaviour may lead to a greater, pre-match anticipatory and/or anxiety effect (Cunniffe et al., 2015) resulting in greater neurogenic drive (Oliveira-Silva et al., 2018). Elevations in these psychophysiological responses may lead to greater performance and contribute to overall success that remain to be explored. However, Fuxjager et al. (2009) noted that it was a combination of *home advantage* and prior winning experience that was key to greater aggressive behaviour and winning. Therefore, an element of the *home advantage* effect may be a long-term adaptation and a result of changes in neural phenotypes (Fuxjager et al., 2010). In male California mice, winning fights was reported to increase the expression of androgen receptors within the brain area associated with

aggression with unique adaptations (i.e. brain areas associated with motivation and reward) developed only after winning within their home territory (Fuxjager et al., 2010). Consequently, *home advantage* may be a result of both acute and chronic adaptations in neuroendocrine function (Carre et al., 2006; Fuxjager et al., 2010; Neave & Wolfson, 2003; Thor & Flannelly, 1976).

While testosterone has been implicated as a physiological contributor to the *home advantage* (Carre et al., 2006; Neave & Wolfson, 2003; Thor & Flannelly, 1976), its contribution has been inconsistent with similar levels noted for athletes involved in home and away matches (Fothergill et al., 2017). In youth and semi-professional soccer players, salivary testosterone levels prior to and following competition were similar for home and away matches, and independent of match success (Fothergill et al., 2017). Further, several studies noted a lack of relationship between testosterone levels and competition success (Carre et al., 2006; Gonzalez-Bono et al., 1999). For example, salivary testosterone levels were similar after a competitive basketball match for winners and losers (Gonzalez-Bono et al., 1999). These authors also reported that salivary cortisol levels were increased similarly for both winners and losers (Gonzalez-Bono et al., 1999). While competition appears to induce stress and elevate cortisol levels, its contribution to winning and a potential *home advantage* remains unclear. For example, greater salivary cortisol levels were identified in youth and semi-professional soccer players prior to and following home compared to away matches, which was independent of match success (Fothergill et al., 2017). For elite, rugby union players, non-starters exhibited greater (effect size of 0.6) pre-match cortisol levels before home matches compared to away matches while starting players exhibited a smaller difference (small effect size, 0.2-0.25) (Cunniffe et al., 2015). Carre et al. (2006) reported non-significantly greater ($p=0.07$) pre-match cortisol levels for elite hockey athletes at home matches. Interestingly, these collective results denoted a substantial stress response for athletes despite competing at home, likely due to the familiar competition site and expected supportive crowd (Pollard, 2006). Competing at home may be considered to be advantageous to athletes in terms of crowd support (Clarke, 2005) and reduced travel effects (Kraemer et al., 2016) however, it may also induce substantial stress on athletes. Changes in psychological states (e.g. arousal and/or nervousness) at home may potentially amplify physiological responses (Fernandez-Fernandez et al., 2015) that contribute to either a positive or negative performance.

Anecdotally, competing away from home has been considered to be a more stressful situation that leads to poorer performance compared to competing at home. For example, salivary cortisol levels were ~8% higher for under 20, professional futsal players when playing away compared to home (Carolina-Paludo et al., 2020). However, no differences in psychological measures or match success was noted between home and away venues (i.e. no *home advantage* exhibited) (Carolina-Paludo et al., 2020). The equivocal findings for cortisol, along with those of testosterone listed previously, highlight the mechanistic complexity for a *home advantage*. It is likely that various factors contribute to a *home advantage* with individual variability in psychological states, and their interaction with endocrine responses, important for athletes' preparation for competition and success (Carolina-Paludo et al., 2020; Cunniffe et al., 2015). Identification of these states and responses, along with implementation of unique interventions to manipulate both (e.g. mindfulness, breathing, supplements, etc), may provide further clarity about the mechanisms for a *home advantage*.

Environmental and travel mechanisms

While changes in endocrine function may contribute to a *home advantage*, environmental and travel factors have been reported to influence athlete and team performance (Brocherie et al., 2014; Brocherie et al., 2015; Fowler et al., 2015; Fowler et al., 2017; McSharry, 2007) that potentially results in a *home advantage*. Brocherie et al. (2014) reported that the Qatar national soccer team experienced a *home advantage* (61.7% wins) across 252 matches over 40 years, likely due to heat acclimatisation of the players. A subsequent study examined the effect of the local weather/environment and opposition ranking on >2000 international soccer match outcomes for six

Arab countries noting a *home advantage* with teams acclimated to the local environment producing greater success (4% per 1°C increase in temperature) against equally ranked teams (Brocherie et al., 2015). Repeated exposures to heat have been reported to induce significant physiological adaptations (Table 1) that likely contribute to beneficial athletic performance (Periard et al., 2015). Subsequently, teams acclimated to their local environment would be more successful at home (Brocherie et al., 2014; Brocherie et al., 2015) while the non-acclimated away team would experience greater fatigue and poorer performance as a result of poorer thermoregulatory and cardiovascular function (Periard et al., 2015).

Table 1. Summary of physiological adaptations to chronic exposure to heat (Periard et al., 2015) and altitude (Bailey & Davies, 1997).

Heat	Altitude
• Greater blood flow to the skin	• Greater number of red blood cells/haematocrit
• Lower skin temperature	• Greater haemoglobin concentration
• Greater sweat rate and sensitivity	• Greater mitochondrial density/volume
• Lower sweating threshold	• Greater aerobic enzyme activity
• Lower core temperature for same absolute exercise intensity	• Greater maximal aerobic capacity
• Greater expression of heat shock proteins	• Greater arterial oxygen saturation during maximal exercise
• Lower heart rate for same absolute exercise intensity	• Lower lactate at submaximal efforts
• Greater plasma volume	
• Greater muscle force production	
• Greater lactate threshold	

To our knowledge, very few studies have expanded upon these initial studies of heat and *home advantage* with acclimation to the local environment possibly inducing physiological adaptations to cope with competition. For example, Pollard (2006) reported that a *home advantage* was greater in countries located in the Andes Mountains compared to other South American countries. McSharry (2007) subsequently examined 1460 football matches between 10 countries noting that the probability of winning at home for a team residing at a high altitude increased substantially (53.7% to 82.5%) when competing against an away team who resided at a lower altitude (i.e. difference of 3695m). The authors proposed that athletes who resided at low altitudes were unable to acclimatise to the high altitude resulting in poorer performance and match outcome for the away team (McSharry, 2007). Therefore, teams regularly exposed to hypoxia and altitude may develop significant physiological adaptations (Table 1) that may contribute to a *home advantage* when competing at altitude. To our knowledge, very few studies have specifically examined these hypoxic-induced adaptations as a contributing mechanism for a *home advantage* with future studies encouraged to elaborate upon our current understanding.

Chronic physiological adaptations to heat and altitude exposure may enhance home team performance and result in a *home advantage* effect. However, travel fatigue or 'jet lag' for the away team may also contribute to this effect (Pollard, 1986, 2006). Goumas (2014) reported that winning at home in the Australian A-League (domestic elite soccer) was significantly greater when the away team travelled across multiple time zones and were suffering from jet lag. Kraemer et al. (2016) reported that trans-American air travel across three time-zones in 3-4 days resulted in jet lag/fatigue symptoms, poor sleep quality, poor performance with minimal changes in melatonin, cortisol, testosterone, and catecholamines. Others have reported that air travel induces poorer sleep/wake behaviour, fatigue, and reduced cortisol responses that lead to poor performance (Fowler et al., 2015; Fowler et al., 2017)

that may contribute to a subsequent *home advantage*. However, travel (i.e. direction and number of time zones covered) was reported to have a limited effect on performances within the National Hockey League (Pace & Carron, 1992) and the Winter Olympics (Balmer et al., 2001) with travel fatigue suggested to be of limited influence for a *home advantage* (Pollard & Gomez, 2015; Smith et al., 2000). Moreover, Smith et al. (2000) concluded that a travel effect may actually be more related to social factors with away teams experiencing disrupted routines and constantly reminded that they are away from home. Despite travel inducing various physiological responses (Fowler et al., 2015; Kraemer et al., 2016), its contribution to home advantage remains to be clearly defined with future work needed.

Conclusion

The overall existence of a *home advantage* in sport has received moderate attention over the past four decades. While some evidence exists for a *home advantage*, the physiological basis for this remains to be clearly demonstrated. Changes in inherent hormone levels, along with psychological states, may contribute to the potentially greater home performance for athletes. Further, *home advantage* may result from environmental acclimation and/or effects of travel fatigue on the away team that remain to be determined. While a *home advantage* may exist and contribute to competition success, significantly more work is needed to clearly identify the physiological mechanisms contributing to such benefit.

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