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## Research Article

# Optimising Lat Activation: A Comparative Analysis of Grip Width in the Bent-Over Barbell Row

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## Abstract

The aim of this study was to understand the effects of grip variation on muscle activation for the latissimus dorsi (LD) in the bent-over barbell row (BOBR). The consensus of surrounding literature is undecided, but still there is a general belief a wider grip warrants a greater level of LD activity. Twenty active male (age, 21.1 ± 1.05 years; stature, 179.6 ± 7.73 cm; mass, 86.1 ± 7.40 kg) university students performed a narrow (100% biacromial) and wide (150% biacromial) grip variation in the BOBR using an experimentally determined load of 60% one repetition maximum (1RM). Three trials of five repetitions were analysed for each grip type. Surface electromyography (sEMG) for both LD was recorded and root mean square (RMS) was captured at the peak of each repetition. sEMG amplitude (mV) was greatest in WG set 3 > WG set 2 > WG set 1 > NG set 3 > NG set 2 > NG set 1. Paired t-test analysis revealed a wide grip to elicit greater muscle activity than a narrow grip ($p < 0.01$). A significant difference was also found between limbs (left = 0.455 ± 0.294 vs. right = 0.361 ± 0.209 mV). Our findings suggest, despite fatigue warranting a greater level of activation, LD activity will always be greater at a wider grip width. Our findings also suggest muscle imbalances are prominent in young active males, meaning one limb often compensates for the other during BOBR.

**Keywords:** bent over barbell row, grip variation, latissimus dorsi, muscle activation, surface EMG.

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## Introduction

In the 21st century, the popularity of resistance training has surged through an influx in fitness centres, driven by a worldwide attentive to health and wellbeing (Laperashvili, 2013). Not long ago, weight training was generally considered to be the domain of exceptionally strong men who competed in sports such as powerlifting, Olympic lifting, and body building, with many athletes believing resistance training would decrease performance in sport (Westcott, 2012). Now, national health organisations across the globe recommend resistance training as a means to deter illness and improve health, with 150 minutes of moderate intensity exercise a week being associated with the prevention of over 25 chronic diseases (Kraemer, Ratames, French, 2002; Garber et al., 2011; Warburton et al., 2007; Kaushal & Rhodes, 2015). A meta-analysis by Westcott (2012) highlighted the greatest effects on type 2 diabetes and lower back pain (Yu & Park, 2017). Furthermore, if practiced concurrently with aerobic training, resistance training has been known to; reduce all-cause mortality (El-Kotob et al., 2020), decrease risk of cardiovascular disease (Saeidifard et al., 2019), and reduce cancer mortality (Stamatakis et al., 2018). There are also several studies that highlight the potential adverse effects on coronary heart disease (CHD) but suggest further exploration (Hollings et al., 2017; Xanthos, Gordon & Kingsley, 2017).

Originally, strength and conditioning were heavily influenced by the bodybuilding philosophy, meaning traditional compound lifts used to dominate the strength development paradigm (Juan, 2001). As fitness enthusiasts continually seek to optimise each exercise, the significance of exercise variation and the impact on muscle engagement and overall performance cannot be overlooked. More recently, the increase in novice lifters has resulted in a shift to new exercise variations and machines designed to help novice lifters build strength more safely through a reduced stability stress (McCaw & Friday, 1994). However, a meta-analysis by Gentil, Fisher & Steele (2016) revealed no benefits in muscle activity when comparing single and multi-joint machine-based exercises. When compared with time-tested traditional compound movements, the surrounding literature suggests that machine-based exercises do not aid performance and rather induce more muscle damage, potentially through an increased eccentric stress (Byrnes, 1986). Nevertheless, resistance machines have demonstrated value in rehabilitation techniques and prolonging athletic careers (Aisen et al., 1997; Juan, 2001).

Building an effective training programme takes careful exercise selection and a delicate balance between the 4 principles of training. These principles: individuality, overload, specificity and reversibility provide a foundation for creating effective personalised programmes. Fitness coaches often find themselves in a quandary: selecting exercises that must be specific enough to target

adaptation, but still varied so reversibility doesn't occur, whilst ensuring the overload and individuality principles are met. While specificity is crucial for attaining set goals, variability ensures holistic development between muscle groups and reduces the risk of detraining (Lambert et al., 2008). Exercise variation can therefore be beneficial and detrimental to achieving set goals (Kassiano, 2022). Many studies have suggested exercise variation could cause greater benefits for strength and hypertrophy compared to simple overload (Fonseca et al., 2014; Costa et al., 2021). This provides undeniable evidence to the importance of exercise quantification, which in turn provides practitioners insight to make informed decisions regarding which exercises are optimal for performance enhancement and rehabilitation (Simenz et al., 2012).

One often overlooked but easily manipulated is the effect of grip width and orientation on upper body exercises (Lusk, Hale & Russel, 2010). Concerning the bench press, a grip too narrow or too wide has been shown to compromise strength and rotate the primary agonist (Wagner et al., 1992; Clemons & Aaron, 1997; Lehman, 2005). A further compound exercise: the deadlift is generally regarded as a leading exercise in strengthening the posterior chain and has been adapted into a diverse collection of variations. As a compound exercise, the deadlift offers remarkable potential for variation in; stance, grip width, grip orientation, posture and equipment used (Piper & Waller, 2001). Similarly, the lat-pull down is perceived as the most effective exercise for targeting the LD, but with little support (Andersen et al., 2014). Many variants of the LPD have been created, through a combination of newly developed equipment and enthusiasts aiming to determine their optimal use, with the general consensus being a wider grip to elicit greater LD activation (Sperandei et al., 2009; Handa et al., 2005; Signorile, Zink & Szwed, 2002; Lee & Lim, 2017). Some studies do not agree, suggesting medium grip width (100% biacromial) and hand orientation to have the greatest effect on LD activation (Andersen et al., 2014; Lusk, Hale & Russel, 2010). It has long been debated how best to develop this muscle, with most research focussing on grip width in machine-based exercises (Lusk, Hale & Russel, 2010; Sperandei et al., 2009; Signorile, Zink & Szwed, 2002). Yet, Alway (2015) has highlighted the importance of incorporating compound exercises like the barbell row. The bent-over barbell row is a compound, multi-joint upper body exercise intended to increase strength of muscles within the upper and middle back, posterior shoulder girdle, and anterior elbow joint consisting of an upward pull and a downward lower (Ronai, 2017). The bent-over barbell row is known to produce the greatest strength and hypertrophy gains, not only in the back but the torso as a whole, which can help stabilize the body in lifting greater loads in different movements (Alway, 2015). The general consensus on the BOBR is undecided, with some finding the greatest activation in the LD and others suggesting it is unsafe to perform (Fenwick, Brown & McGill, 2009; García-Jaén et al., 2021; Loturco et al., 2021). If differences

in LD activation between grip widths exist, it is crucial to understand these differences for the application of the bent-over row in sports for most optimal development of the LD. Accordingly, this study aims to add an insight into grip variation in the bent-over barbell row to instruct its administration for optimal exercise efficacy.

## Methods

*Ethical Clearance*

Institutional ethical approval was acquired from Northumbria University Ethics Department and informed consent was obtained in Visit 1.

*Design*

The presented study is a pilot study intended to add insight to the effectiveness of the current data collection method. This study has a quantitative experimental design that assesses the relationship between grip width and muscle activation. All participants were required to visit the Northumbria University Integrated Performance Lab twice. Firstly, as a familiarisation session to understand; what is required of them, the study, the equipment and to address any contemporary issues that may arise during the experimental session. This session will also give opportunity to have age, stature and mass recorded followed by a standardised warm-up and three sets of a gradually increasing load up to their estimated five rep max (5RM) of BOBR at their typical grip width to instruct the second session. Secondly, to complete the presented experimental protocol. Considerations were made to reduce fatiguing factor – 48hr exercise free period before each session and exercise order was randomised and counterbalanced using a random number generator.

*Participants*

A sample size of 16 was established using previous literature from McAllister et al. (2013) using a similar protocol in a separate row variant with weight-trained men. 20 young active healthy male Newcastle & Northumbria University students (age, 21.1 ± 1.05 years; stature, 179.6 ± 7.73 cm; mass, 86.1 ± 7.40 kg) volunteered to take part in this study. Inclusion criteria: 18–40 year-old males who regularly take part in gym-based exercise 3-4 times per week, with 6 months experience of weightlifting in the rowing position and a rough idea of 5RM. Exclusion criteria includes males above the age of 40 or under 18, females, injured, sedentary. Females were excluded due to the potential menstruation cycle effect between weeks (Rodrigues, de Azevedo Correia & Wharton, 2019). Participants were made aware of the potential exercise risks prior to data collection. When working with heavy loads in the BOBR improper execution can cause injury (Ronai, 2017). As with any form of

exercise there may be a level of discomfort and muscle soreness post-exercise (Cheung, Hulme, Maxwell, 2003).

*Surface Electromyography*

sEMG was used to quantify muscle activation (millivolts [mV]). Participants were made aware of the potential contemporary issues that may occur when working with sEMG. Certain factors such as skincare products or body hair can affect the strength of the impulse read by the sEMG receptors (Hewson et al., 2003). Prior to data collection, EMG equipment was set up and tested by the researcher to ensure proper signal transmission and reception. The Delsys Trigno base station was connected to a nearby Northumbria University computer possessing Delsys EMGworks acquisition software. All respective skin sites were cleaned & abrased using alcohol wipes (Medisave Pre-Injection Swabs [70% IPA Alcohol]) and cases of excessive body hair were shaven (Hermens et al., 2000). The software was then opened and charged electrodes were assigned to each LD. The concerned electrodes were then removed from the base station and were also cleaned & abrased. Adhesive strips were then attached for placement. Electrode (Delsys Trigno Research + – DelsysInc, Natick, MA, USA) (Figure 1) placement was attempted in accordance with SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles); however, no directions were published for the LD, as previously noted by Park & Yoo (2013). Electrode placement was located using previous literature from Soltani & Vilas-Boas (2016) by palpating the scapula; placing the electrodes approximately 4 cm below the inferior border of scapula, half the distance between the spine and the lateral edge of torso and positioned almost 25 degrees obliquely. Electrodes were turned on and participants were asked to contract their LD to ensure proper signalling. Data was then collected and exported to Delsys EMGworks analysis. One RMS sample was taken at the peak of each repetition for each LD.

**Figure 1.** Delsys Trigno base station employed in this study.

*Procedures*

*Visit 1: Familiarisation Protocol*

The familiarisation and strength testing took place within the Northumbria University IPL, January 2024. Participants age (years), stature (cm) (SECA 213 STADIOMETER – Medisave UK Ltd, Dorset) and mass (kg) (SECA Scales 711 – Seca Ltd, Birmingham) and biacromial diameter were recorded. Each participant was palpated in the back of both shoulder girdles to determine the location of their acromion process'. Biacromial diameter is defined as skeletal breadth which is the distance between both landmarks and was found using the exact same method as Stoudt (1970). Biacromial diameter was noted down for each participant and multiplied by 1.5 to achieve 150% biacromial. Each participant was run through a standardised warm-up of rotations, stretches and contractions consisting of; 10 iso arm circles, 8 elevation dead hangs, 10 banded medial & lateral shoulder rotations, 10 banded shoulder elevations, 12 banded face pulls followed by 5 band-assisted pull ups. Exercises were performed on a pull up bar situated within in the IPL and the band utilised was a Myprotein (2-16 kg) band. Exercises were performed in this order and when unilateral warranted the dominant hand was exercised first. Participants were then familiarised with both movements, environment, movement amplitude, body position and the cadence of movement that would be employed in the experimental session (Figure 2). Participants practiced each movement until both they and the researcher felt confident the correct technique had been executed. Participants were then asked to complete three sets of five repetitions BOBR at a gradually increasing submaximal load up to 90% 5RM. Participants were then asked to complete one set of their assumed 5RM at their typical grip width. If form was compromised, participants were instructed to take five minutes rest, and decrease the load by 2.5 kg until an actual 5RM value was achieved. Brzycki's equation was then used to assume 1RM, as previously demonstrating a valid and reliable method in college football players (DiStasio, 2014). Equation 1 displays Brzycki's equation (DiStasio, 2014). The value attained was then multiplied by 0.6 to attain 60%1RM to instruct the experimental session. This value was always lower than the 5RM.

**Equation 1**:

$$1RM = \text{rep wt} / (102.78 – 2.78 [\text{reps}])$$

Brzycki (1993)


**Figure 2.** Image of the form employed in this study, as recommended by Ronai (2017).

*Visit 2: Data Collection*

One week later, data collection also took place within the Northumbria University IPL. Participants were once again made aware of the contemporary issues surrounding sEMG. All skin sites were cleaned & abrased and participants with disrupting body hair were shaven. Electrodes were then placed on both participants LD in accordance with guidelines from Soltani & Vilas-Boas (2016) (Figure 3). Participants were once again run through the standardised warm-up of rotations, stretches and contractions. Participants were then instructed to perform one set of eight repetitions of an empty barbell (20kg). The load of the bar was then increased to 30kg, a set of six repetitions was performed, the load was then increased to the studied 60%1RM. A measuring tape was used to instruct grip width for the participants. Participants were then instructed to grip the bar at either narrow (100% biacromial) or wide (150% biacromial) grip width, perform five repetitions of BOBR, rest for three minutes then repeat twice. Following the third set, participants rested for 5 minutes and then began the same protocol at the other grip width.

*Data Analysis (EMG)*

sEMG amplitude was extracted from Delsys EMGworks Acquisition software and opened in Delsys EMGworks Analysis. Maximal RMS amplitude values for both LD during each repetition was snapped and exported to excel.

*Statistical Analysis*

A paired samples T-test was used to identify EMG differences between grip widths. Statistical significance was accepted at $p < 0.05$. A separate paired samples T-test was also used to identify differences between limbs. Data was imported to SPSS to reveal differences between sets & repetitions. A paired samples correlations test was run between grip widths and limbs to identify participant patterns across protocols. Values presented are mean RMS ± SD to three decimal places (3 dp).

## Results

Mean EMG amplitude was greater during wide (0.439 ± 0.263 mV) compared to narrow (0.378 ± 0.252 mV) grips ($F_{1.99, 792.05} = 13.9$, $p < 0.001$), with no interaction between grip width and sets performed ($p > 0.05$). A correlation was found between groups (0.861, $p < 0.05$) (Figure 4). A paired samples T-test revealed differences in mean muscle activation between the left (0.455 ± 0.294 mV) and right (0.361 ± 0.209 mV) LD. Differences in mean muscle activation across the three sets between repetitions were as follows; for the left LD NG: mean muscle activation decreased between repetitions. For the left LD WG: mean muscle activation increased at repetition 2 and then decreased. For the right LD NG: mean muscle activation decreased until the final repetition. For the right LD WG: mean muscle activation decreased (see Figure 5).

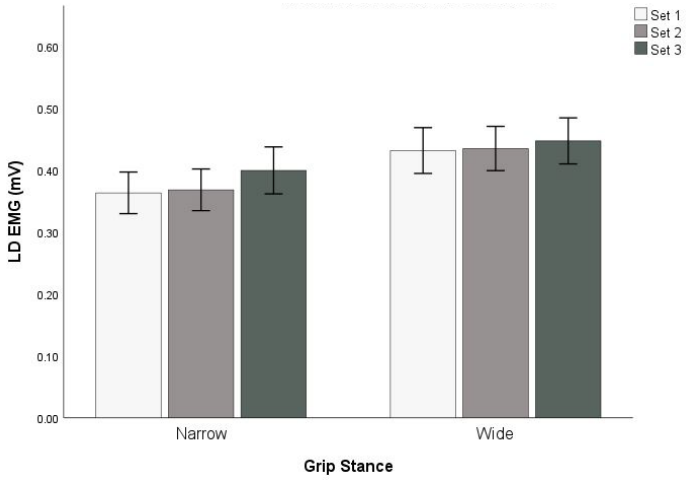


**Figure 4.** Mean (n = 20) RMS EMG for the LD during different grip widths (wide and narrow) across sets.

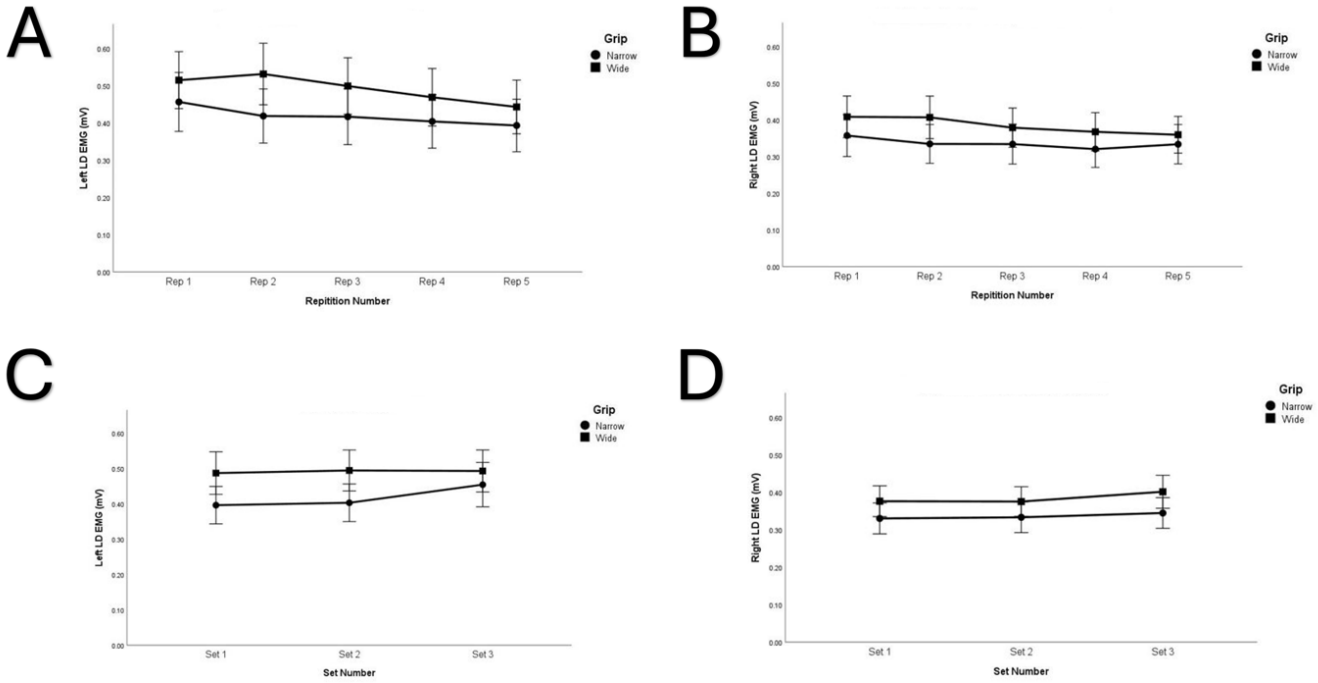


**Figure 5.** Mean (n = 20) RMS EMG for the left (A & C) and right (B & D) LD during narrow and wide grip widths between sets (C & D) and repetitions (A & B)

## Discussion

The selection of grip width is a fundamental facet in any weightlifting programme, playing a pivotal part in exercise kinematics, thus playing an indespensable role on muscle recruitment patterns and overall performance. From the bench press to the deadlift, the width at which an individual grips the bar profoundly influences the biomechanical demands placed on the respective joints and muscles (Wagner et al., 1992; Kasovic, Martin & Fahs, 2019). Consequently, the safety and efficacy of the exercise can be enhanced, adapted or diminished. If a relationship between grip width and muscle activation exists, this would be crucial for athletes, coaches, fitness entheusiasts and future researchers to know, as insight could help optimize training routines, reduce injury risk, and above all, enhance performance. The aim of this study was to investigate the impact of grip variation on muscle recruitment in the bent-over barbell row.

The key finding of this investigation is that LD sEMG amplitude increases with corresponding grip width. This finding is in accordance with our original aim to determine the relationship between grip width and LD activation. This finding is also in agreement with 4 previous investigations that have shown significant changes in muscle activation in response to a wider grip during upper-body pulling exercises such as the upright row and LPD (Signorile, Zink & Szwed, 2002; Lusk, Hale & Russel, 2010;

McAllister et al, 2013; Lee & Lim, 2017). Lee & Lim (2017) employed a near identical protocol, using the same measurement scale, when reviewing muscle activity between grip widths in the LPD. Exhibiting similar findings, proving a greater level of activation in the anterior trunk muscles (pectoralis major & rectus abdominis) when using a narrow grip (100% biacromial) and a greater level of activation in the LD when using a wide grip (150% biacromial). Signorile, Zink & Szwed (2002) investigated further, aiming to determine the most optimal grip for LD activity in the LPD between four grips: wide grip anterior (WGA), wide grip posterior (WGP), supinated grip (SG) and close grip (CG). Reporting the WGA to be optimal for maximally recruiting the LD. Other researchers have added to this, offering the WGP and seated row to elicit the most activation, suggesting the BOBR to be suboptimal for recruiting the LD, but optimal for the upper, middle and lower trapezius (Handa et al., 2005; Lehman et al., 2004). However, the WGP has been shown to cause injury by stressing the glenohumeral ligaments extensively and should be avoided (Crate, 1997; Sperandei et al., 2009). Lusk, Hale & Russel (2010) set out to determine if grip orientation had a greater effect than width. Finding no difference between grip width but significant differences between orientation, recommending a pronated grip (2010). Lehman et al. (2004) found the opposite, reporting no differences between grip orientation, but differences between LD targeted exercises, but stated the relative changes were small, and may have no effect on weight training significance. Our finding is also comparable to those surrounding compound exercises for different muscle groups. The deadlift is an exercise targeted on strengthening the lower body and posterior chain. Many variations have been developed and researched, with each varying activation across a range of muscles (Martín-Fuentes, Oliva-Lozano, & Muyor, 2020). A wide grip is typically only employed in the Romanian deadlift (RDL) & snatch deadlift and holds advantage over other variations by warranting a greater level of upper back strength and scapular & spinal stabilization (Piper & Waller, 2001). Concerning the bench press, Clemons & Aaron (1997) reported activity increases in the prime movers when employing a wider grip. This finding was credited to the potential increase in torque around the shoulder joint (Clemons & Aaron, 1997). Similarly, one possible explanation for our finding is due to the greater degree of humeral abduction; a wider grip better aligns with the muscle fibers and is more specific to the LD movement plane (McAllister et al., 2013; García-Jaén et al., 2021).

This study also found amplitude differences between limbs. Paired T-test analysis of mean sEMG revealed significantly greater activation in the left LD. Similarly, Flint et al. (2015) also found the left LD to activate more and creditted the finding to the potential effects of; a small sample size, hand dominance, or a limited familiarisation period. With the high level of detail in the familirisation session, it is unlikely our finding can be creditted to this. However, the present sample size is small and is a

viable cause. Yet, despite hand dominance not being recorded in this study, it is thought to be the most likely cause of this finding. Muscular imbalances can occur through a variety of means, particularly by hand dominance. Daily preferential use has been shown to alter physiological and mechanical properties of skeletal muscle (Adam, Luca & Erim, 1998). Thus, during compound lifts, it is not uncommon for bilateral muscle pairs to activate at different rates and to different extents. With an estimated 10.6% of people being left handed, it is fair to assume the left LD often had to activate more to keep up with the right (Papadatou-Pastou et al., 2020). Further research is needed to understand the true cause of this finding, with a greater sample size and a measure of hand dominance. Further insight could be valuable to coaches, athletes and physiotherapists as muscular imbalances are related to acute injuries (Croisier, 2004). This insight could help identify muscular imbalances earlier and allow for informed targetted exercise selection to prevent injury.

Irrespective of grip width, both LD exhibited a linear increase between sets at 60% 1RM, with the acception of the left LD WG set 3 and right LD WG set 2 which both saw a non-significant decline. Mean scores from the repeated measures ANOVA indicate sEMG amplitude will increase with sets linearly. Many studies have examined the relationship between sEMG amplitude and muscle activation, with it now being an accurate measure of fatigue index (Lowery & O'Malley, 2003; Cifrek et al., 2009). However, very few studies report sEMG amplitude between sets and repititions when not working to failure. When investigating muscle activation to failure at 80 & 30% 1RM, Jenkins et al. (2015) found, in the 80% 1RM group, only one of eight subjects to exhibit a linear increase in EMG amplitude between sets, suggesting muscle activation at 80% 1RM remained at similar levels across all repititions and sets. However, in the 30% 1RM group, Jenkins reported a significant decline in EMG aplitude between sets. This contrasts with our findings and suggests fatigue index may differ at different %1RM. This also contrasts with previous literature from Jenkins et al., finding the same decline between sets in the 80% 1RM group, but a linear increase in the 30% 1RM group (2015). The main differences between our investigation and both of Jenkins' is the studied muscle groups and extent of fatigue (failure/nonfailure). Factors such as location, architecture, bloodflow (Yasuda et al., 2009), or fiber type compisition of the musculature may influence the recruitment response to different %1RM and to what extent. Combined, the present findings suggest muscle recruitment in response to different %1RM loads must be specific. Future studies should look to define these specifics, investigating the same muscle group at different %1RM.

Despite increasing between sets, a decrease in sEMG amplitude was observed between repetitions. Agreeing with previous research from Augustsson et al. (2003), who found a reduction in activity across

repititions when reviewing activation for lower limb muscles in the leg press. This finding contrasts previous literature from Sundstrup et al. (2012). When reviewing the physiological effects of training to or near to failure (3RM) with elsastic resistance in untrained women, normalised sEMG values for the failure group increased in a curvilinear fashion until hitting a plateau in the final repititions, whereas the 3RM group displayed very similar levels throughout (Sundstrup et al., 2012). Suggesting going to complete failure is unnecessary when aiming to recruit the entire motor unit (Sundstrup et al., 2012). The main differences in this study are the social group, musculature and type of resistance investigated. Several studies have investigated the effects on recruitment between mode of resistance, with those agreeing mode can heavily influence lifting velocity and thereby muscle coordination and activation, particularly in elastic resistance (Duffey & Challis, 2012; Izquierdo et al., 2006; Aboodarda, Page & Behm., 2016). It is no secret muscles respond differently under the manipulation of different training variables (rest, velocity, load, mode, volume) (Sundstrup et al., 2012). By such means, this finding could have a similar explanation to that of Sundstrup et al. (2012). Amplitude cancellation occurs when the respective elecrtodes underestimate the amount of motor unit activity due to the loss of information that occurs when overlapping positive and negative phases of motor unit potentials cancel one another out and reduce the signal (Keenan et al., 2005; Day & Hulliger., 2001). With the back being one of the largest and complex muscle groups, it is a valid explanation for the observed decrease in amplitude (MacDonald, Moseley, Hodges, 2009). Amplitude cancellation has been recognised for decades, yet only one study has quantified amplitude interference using intramuscular EMG (Keenan et al., 2005). With Day & Hulliger (2001) finding a 50% reduction in intramuscular EMG amplitude in cats, suggesting a MVC to be necessary for more accurate and reliable results. Future studies should explore the use of intramuscular EMG, with a measure of MVC.

*Conclusion*

This is the first study to assess bilateral activation of the LD between grip widths. The primary findings indicate that in the BOBR, LD activity remained greater at the wide grip when compared to narrow. This is thought to be through the greater degree of humeral abduction, being more specific to the LD movement plane. A greater level of activation was observed in the left LD, this finding was attributed to hand dominance. LD activity increased between sets, this finding was credited to fatigue, as the demand increases, greater activation of the muscle is required to maintain performance. LD activity decreased between repititions, this finding was credited to cross-talk cancelling out sEMG amplitude. Future studies are needed to determine the optimal grip width for LD activation and to further examine the interaction with articulating muscles at varied loads to determine a load-activation relationship for the LD in the BOBR.

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## Research Article

# The effect of sleep on swimming performance

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## Abstract

There has been extensive research on sleep, including the stages, deprivation, and importance. However, there is limited research into the importance of sleep for athletes, especially swimmers. Therefore, the aim of the study was to investigate if quality of sleep affects swimming performance in university level swimmers. Eleven student-athletes from a university swimming team completed a timed 50 and 200 m freestyle swim in the morning and evening. Participants completed the Pittsburgh Sleep Quality Index questionnaire (PSQI) and Elite Performance Readiness Questionnaire (EPRQ) prior to the swims. Differences between AM and PM swims were analysed using either a paired t-test or Wilcoxon signed rank test, with Spearman's rank correlations used to assess strength of relationships. The 200 m swim was faster in the evening compared to morning (P = 0.013) with no difference observed for the 50 m swim (P = 0.102). There was no correlation between PSQI scores and swim time (rho [ρ] = −0.22). Eight out of the 11 swimmers (66%) were deemed to have poor quality sleep. The results highlight the importance of sleep and understanding the effects of sleep deprivation and reveal that athletes performed better in the evening compared to the morning. This is important when planning competitions and training programs, understanding that athletes perform better in the evening when they're potentially more motivated and alert. Our results could be considered for British Universities and Colleges Sport events, as performance standard seems to be greater, later in the day.

**Keywords:** EPRQ, PSQI, sleep deprivation, student athletes, university swimmers.

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## Introduction

For overall wellness, sleep is essential (Brinkman et al., 2020), however, sleep is a very complex process, and the exact purpose of it is not clear (Brinkman et al., 2020). Numerous hypotheses have investigated the brain and tried to pinpoint a reason for why humans sleep. There is no exact reason as to why humans need sleep, but a combination of reasons explains the importance. Sleep is essential for many brain processes, including the communication between neurons (National Institute of Neurological Disorders and Stroke, 2022). There has been extensive research into the stages of sleep. There are two types of sleep: rapid eye movement (REM) sleep and non-REM (NREM) sleep. During REM sleep, brain activity increases, and the muscles become temporarily paralysed (Suni, 2021). Clusters of sleep-promoting neurons become more active, whilst neurotransmitters reduce the activity of cells (National Institute of Neurological Disorders and Stroke, 2022). REM sleep occurs around 90 minutes after initially falling asleep, and your eyes move rapidly behind closed eyelids (National Institute of Neurological Disorders and Stroke, 2022). For cognitive processes like memory, learning, and creativity, REM sleep is thought to be required (Suni, 2021). NREM sleep consists of 3 stages: N1, N2, and N3. N3 is the stage of deep sleep, also known as slow wave sleep (SWS). It is hard to awaken when in this state, and heart rate and breathing rate are at their lowest (National Institute of Neurological Disorders and Stroke, 2022). N3 is important for muscle and tissue repair, as well as memory consolidation (Wiginton, 2024).

Sleep is also a crucial component of both physical and mental well-being (Capezuti, 2016) and teenagers are recommended to aim for between 8 and 10 hours per night (Gudmundsdottir, 2019). A consistent and good quality sleep schedule comes with many benefits: improved immunity, mental and physical well-being, memory consolidation, hormone balance, and reproductive health are all facilitated by getting enough sleep (Baranwal et al., 2023). There are many people who suffer from sleep deprivation, and while the effects on the general population have been extensively studied, there are few research studies that specifically address the impact on athletes (Vitale et al., 2019). Many people experience sleeping difficulties or receive less sleep than is advised (Capezuti, 2016). Therefore, it is important to study sleep health and the consequences of poor sleep quality and deprivation. In addition, sleep disturbances are linked to high rates of daytime functioning impairment, poor job performance, crash rates, and increased pain perception (Baranwal et al., 2023). An increase in the rate of disease can result from sleep disorders such as insomnia, sleep apnoea, and circadian rhythm disorders, as well as disrupted sleep brought on by lifestyle decisions, environmental factors, or other medical diseases (Baranwal et al., 2023). These disorders can also worsen or cause other medical and psychiatric conditions (Baranwal et al., 2023). Intraindividual variability in sleep has also been linked

to several physical and neurodevelopmental conditions in children and adolescents, as well as psychopathological symptoms, weight, stress, cognitive functioning, and poorer sleep habits (Gudmundsdottir, 2019). Consistency of sleep patterns (e.g., bedtime and sleep duration on weekdays vs. weekends or night-to-night variability) may also affect restitution and health in addition to average sleep duration (Gudmundsdottir, 2019). Lack of sleep has negative impacts on decision-making, affecting speed and accuracy, having a detrimental impact on overall task performance. Sleep loss heightens fatigue and negatively impacts cognitive performance, mood, and post-exercise recovery (Troynikov et al., 2018).

It has been suggested that adult elite athletes need more sleep than the 7–9 hours advised each night to meet prolonged training loads in the best possible health. But prior research has shown that elite adult athletes frequently get inadequate sleep (Gudmundsdottir, 2019). According to a study conducted on tennis players, serve accuracy increased from around 36 to 42% when sleep was raised to at least 9 hours per night (Fry & Rehman, 2021). Ochoa-Lácar et al.'s (2022) systematic review also revealed that basketball players who had increased sleep quality and duration had better performance and a lower chance of injury. There is limited research on swimmers; however, current literature shows the majority have extremely short total sleep time prior to early morning sessions, and total sleep time variability increases with more early morning sessions (Gudmundsdottir, 2019). A study showed that when sleep was increased to a 10-hour period, performance was improved in both male and female elite swimmers (Fry & Rehman, 2021); kick strokes increased, turn times decreased, and reaction times off diving blocks were quicker along with a 15-meter sprint swim time improvement. These athletes also reported feeling happier, less tired, and sleepy during the day (Fry & Rehman, 2021). A study by Nunes et al. (2021) investigated the impact of time of day on swimming performance (50, 200 and 400 m). It was found that 50 and 200 m swimming performance in boys was similar at both times, but overall performance improved in the evening in the 400 m swim. There are very few studies on student athletes. University student athletes differ from other populations due to the unique lifestyle of socialising and studying, and a greater sense of freedom. Previous research on sleep has been undertaken on adults and other groups of athletes such as football and basketball players (Ochoa-Lácar et al., 2022). As noted, literature has shown the importance of sleep for overall health and wellbeing but there are few existing studies focusing on the importance of sleep for general athletic performance. The present study aims to investigate if sleep quality affects swimming performance in university level swimmers. The hypothesis was that lower quality of sleep leads to lower swimming performance. It was also hypothesised that swimmers would perform better in the evening than the morning.

## Methods

*Participants*

Eleven student-athletes (age 19 ± 1 years, stature 170 ± 11 cm, body mass 67 ± 12 kg; 3 males, 8 females) from a University Swimming Team gave written informed consent to the study. The study received ethical approval from the Northumbria University Faculty of Health and Life Science Ethics committee. A sample size of 19 was determined by the following three studies; Nunes et al. (2021; 33 participants), Mah et al. (2011; 11 participants), and Schwartz and Simon, (2015; 12 participants). However, due to the amount of people willing to participate, only 11 were recruited. The following inclusion criteria were considered prior to testing: (1) all participants train two to three times a week for 60–90 minutes, (2) have at least two years' competitive experience. The exclusion criteria included the following: (1) participants who consumed alcohol 24 hours prior to the study, (2) participants who took place in strenuous physical activity for the study's duration or 24 hours prior to the study. The study took place two weeks after the competitive season, to ensure all participants were in a good competitive condition and familiar with the distances. Before collecting data, participants were informed of the potential risks (normal training risks, e.g., cramps, stitches) and potential benefits along with providing written informed consent.

*Protocol*

Participants completed the Pittsburgh Sleep Quality Index (PSQI), which evaluates sleep quality over one month. The questionnaire consists of 19 items, which combine to form 7 components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disruptions, usage of sleeping medication, and daytime dysfunction), which together produce an overall score (0-21). Participants scoring 0-4 indicates good sleep, between 5-10 points indicates poor quality sleep, and points 11-21 presents a sleeping disorder (Nunes et al., 2021). Backhaus et al. (2002) found that the PSQI questionnaire has high test-retest reliability and good validity, along with been validated with many clinical populations (Shahid et al., 2011).

This study was a repeated measures design. Participants completed the Elite Performance Readiness Questionnaire (EPRQ) prior to training. The EPRQ consists of 10 items, giving a quick assessment of performance readiness. Each question is answered by marking a vertical line on a 10 point (100 mm) visual analogue scale. The questionnaire is made up of two components. The first component is the Brief Assessment of Mood (BAM) (a shortened version of the Profile of Mood States [McNair et al., 1971] created by Dean et al., 1990). The BAM includes 6 adjectives (Angry, Alert, Fatigued, Depressed, Confused, and Tense) for the participant to indicate how they feel about each mood at that current

time. A study by Shearer et al. (2017) showed the effectiveness and reliability of the questionnaire to measure and monitor recovery in footballers. The original BAM questionnaire had limitations, and by extending it (adding confidence, motivation, muscle soreness and sleep quality) allowed athletes to broaden and give more in-depth responses. In addition to other more invasive techniques, mood-based assessments of perceptual fatigue offer a non-invasive way to gauge recovery status. Participants completed the questionnaire (using pen and paper) before training on a morning (0700 hrs), and the following day in the evening (1800 hrs). Participant times were compared between morning and evening for both 50 and 200m. The 50 m sprint was performed first, as it predominately uses the anaerobic energy system and on average only lasts 25-35 seconds. The 200 m swim predominately uses the aerobic system and lasts from 2-3 minutes. By doing the 50 m sprint first, it will not affect the performance of the 200 m. The method used was informed by Nunes et al. (2021) study that examined the impact of time of day on performance in adolescent swimmers. In their study, the athletes performed a timed 50 and 400 m, both in the morning and evening. However, in the present study, only the 200 m was used due to the time available and the athletes being more inclined to participate in a 200 m swim, rather than 400 m.

The swims took place in a 25 m pool with a water temperature between 27-28°C (Sport Central, Northumbria University). Participants completed a standardised warm-up, consisting of 400 m freestyle, 100 m backstroke, 100 m medley (butterfly, backstroke, breaststroke, and freestyle) and 4 × 50 m kick. They then performed a timed 50 and 200 m freestyle swim from a dive start which was timed by a handheld stopwatch. Rate of Perceived Exertion (RPE) was also recorded after each swim using the Borg scale (Williams, 2017). The scale is a valid measure of exertion and has a very large correlation with % heart rate (Arney et al., 2019).

*Data Collection and Analysis*

Statistical tests for discrete variables were performed using IBM SPSS Statistics (v28, IBM UK Ltd, Portsmouth, UK). The data were tested for normality and analysed using either a t-test or Wilcoxon signed rank test depending on normality. A paired t-test was used to compare 200 m swim times between AM and PM, and a Wilcoxon matched pairs test was used to compare 50 m swim times between AM and PM. A Spearman's rho test was used to assess the correlation between PSQI scores and swim times. A Wilcoxon test was used to analyse the correlation between RPE and PSQI scores. Correlation of swim times and sleep quality were analysed using Spearman's correlation coefficients. The correlation coefficients were interpreted according to Batterham and Hopkins (2006) as trivial (0.0), small (>0.1), moderate (>0.3), large (>0.5), very large >0.7), nearly perfect (>0.9) and perfect

(1.0). EPQR scores were analysed using a paired t-test. The level of statistical significance was $P \leq 0.05$. The data was also analysed using multiple linear regression to the EPRQ questions predicted swimming performance. The dependent variable was the swimming times, and the independent variables (predictors) were the EPRQ questions. There were too many variables to analyse once, therefore this was repeated multiple times to find the strongest predictors for swimming performance.

## Results

For the 50 m swim, there was no difference between morning and evening performance (32.64 ± 4.63 vs. 31.46 ± 4.60 s; P = 0.102). Mean RPE was also comparable, showing participants found both performances equally as hard (Table 1). For the 200 m swim, performance was greater in the evening compared to the morning (160.27 ± 34.78 vs. 162.31 ± 35.37 s; P = 0.013). However, mean RPE was comparable (P = 0.192, Table 1).

**Table 1.** RPE values for 50 and 200 m swims, during AM and PM.

| Distance (m) | Mean (SD) | | P value |
|---|---|---|---|
| | AM | PM | |
| 50 | 15 ± 1.03 | 15 ± 0.98 | 0.192 |
| 200 | 14 ± 1.12 | 15 ± 1.0 | 0.132 |

*Values are mean (± SD).*

The PSQI readings ranged from 2 to 13. Three participants were considered to have good sleep, seven deemed poor-quality sleep, and one with a sleeping disorder (Table 2). The PSQI scores showed no correlation between either the AM 200 m (rho [ρ] = −0.13) or the PM 200 m (rho [ρ] = −0.22). Sleep quality showed a weak correlation with the AM 200 m, and the PM 200 m showed a stronger correlation coefficient. RPE was correlated to PSQI scores (P = 0.003). Perceptual responses (Table 3) in the Elite Performance readiness questionnaire show that fatigue decreased prior to the PM session (P = 0.006). Alertness was also higher in the PM session compared to the AM session (P = 0.002).

**Table 2.** 200 m swim times for good and poor-quality sleep

| Sleep Quality | Mean (SD) | | P value |
|---|---|---|---|
| | AM | PM | |
| Good | 156 ± 17.79 | 153 ± 17.35 | 0.242 |
| Poor | 164 ± 40.95 | 162 ± 40.16 | 0.111 |

*Values are mean (± SD).*

**Table 3.** Perceptual responses measured using EPRQ, during AM and PM.

| Variable | Units | Mean (SD) | | Mean | P value |
|---|---|---|---|---|---|
| | 0-10 | AM | PM | difference | |
| Angry | | 1.26 ± 0.91 | 1.95 ± 1.97 | 0.68 | 0.279 |
| Confused | | 3.04 ± 2.29 | 2.39 ± 2.34 | -0.65 | 0.402 |
| Depressed | | 1.9 ± 1.83 | 1.74 ± 2.01 | -0.16 | 0.693 |
| Fatigued | | 5.84 ± 1.49 | 4.08 ± 1.65 | -1.75 | 0.006* |
| Tense | | 4.45 ± 2.05 | 3.57 ± 1.64 | -0.87 | 0.135 |
| Alert | | 2.54 ± 2.02 | 6.22 ± 1.63 | 3.68 | 0.002* |
| Confident | | 4.15 ± 2.14 | 5.81 ± 1.73 | 1.65 | 0.042 |
| Sore | | 5.35 ± 1.41 | 4.95 ± 1.89 | -0.39 | 0.581 |
| Motivated | | 3.07 ± 2.41 | 6.01 ± 1.91 | 2.94 | 0.010 |
| Sleep | | 5.12 ± 2.27 | 5.19 ± 1.7 | 0.07 | 0.922 |

*Values are mean (± SD). Significant differences between AM and PM indicated by * P ≤ 0.05*

Multiple linear regression (Table 4) shows all R values are >0.9, showing a 'nearly perfect' correlation between EPRQ and swim performance (Batterham & Hopkins, 2006). The $R^2$ values show that the variables from the EPRQ questionnaire are good predictors (91 to 99%) of swimming performance (different variables were used for each analysis) of the independent variables (EPRQ questions), only one showed significance: confidence for the AM 50 m (P = 0.048).

**Table 4.** Multiple linear regression values for 50 and 200 m, during AM and PM.

| Time of day | Distance (m) | R | $R^2$ |
|---|---|---|---|
| AM | 50* | 0.993 | 0.985 |
| | 200 | 0.980 | 0.960 |
| PM | 50 | 0.975 | 0.951 |
| | 200 | 0.954 | 0.910 |

*Values are mean (± SD). Significant differences between AM and PM indicated by * P ≤ 0.05*

## Discussion

This study aimed to assess if sleep quality affected swimming performance and established a difference in swimming performance between the morning and evening. However, as there was no difference between good and poor-quality sleep on swimming performance, other factors may influence performance other than sleep. A difference was found in the 200 m swim between morning and evening, with most swimmers performing better in the evening, supporting the initial hypothesis. However, there was no difference in the 50 m swim between the morning and evening sessions and RPE was similar for both 50 and 200 m swims. No differences in 200 m performance were based on

sleep quality. Participants felt more fatigued in the morning and more alert in the evening, which may have had an influence on performance.

An increase in 200 m performance was found in the evening, a result in line with previous research by Nunes et al. (2021), where increased performance was found in 400 m performance. Their finding was driven by boys performing better in the evening and not girls, signifying that sex may have an impact on swimming performance in the evening. Madge (2014) analysed data to determine if a 200 m swim was classified as a sprint or a distance event. The results of the analysis showed 200 m is a distance event, as the top swimmers for 400 m were closer to the fastest 200 m mean swim times compared to the fastest 50 m swim times. Therefore, as 200 m is a distance event, it is easier to see the difference in performance (time) due to factors such as fatigue. Research shows that sleep deprivation affects endurance performance, as participants may be less motivated to endure discomfort (Thun et al., 2015). It is also shown that sleep deprivation reduces the time to exhaustion (Thun et al., 2015).

Results of the present study are also in line with research by di Cagno et al. (2013), where elite gymnasts performed better in the evening in coordination tests and reactive strength. Another study by Pullinger et al. (2019) showed that repeated sprint performance was greater, later in the day (1700 – 1900 hrs) than in the morning (0600 – 1000 hrs). A study by Klaus-Karwisch et al. (2023) found an increase in sprint and jump performance in the evening, in female sports students. It has also been suggested that an increase in body temperature correlates with a higher activation of fast twitch fibres, possibly explaining an increase in performance later in the day (Klaus-Karwisch et al., 2023). The body temperature follows the circadian rhythm, with its lowest values in the morning and its highest values in the afternoon and evening (Harding et al., 2020). It is important to understand and apply this knowledge to training regimens and competitions, to receive the best results from athletes. This may impact coaches' decisions when deciding what type of training is best for swimmers in the morning and evening. From this study's results, swimmers should complete more high intensity distance work in the evening. This is in line with finals usually taking place in the evening, at major events such as the Championships and Olympic games.

EPRQ variables were found to predict swimming performance (>91%). Owens et al. (1998) also suggested that alertness (an EPRQ variable) can be used to predict time-of-day effect on performance (di Cagno et al., 2013). Research shows that sleep deprivation can reduce performance by decreasing motivation (Thun et al., 2015) and this is in line with the present data where increased performance was found in the PM 200 m swim, where alertness and motivation increased. There was no difference found in the 50 m swim between the morning and evening sessions. This also reflects the results of

Nunes' study, showing no time-of-day effect for 50 m. As 50 m is a sprint event, it is considered easier to stay consistent. Therefore, it is not surprising that differences were not found due to the short distance. Research suggests that short-term high-power tasks are unaffected by one or several nights of sleep deprivation (Thun et al., 2015). In sprint events (50 and 100 m), most of the race is down to skill. The first 15 meters relies on the dive and underwater; the 5 m into the wall and 5 m out of the wall are determined by turn technique, wall power and underwater, and the last 5 m is dependent on finishing skills (Goldsmith, 2018). Therefore, for a 50 m sprint, 30 m of it is down to skill. As the participants were all experienced swimmers, the level of skill is unlikely to change throughout the study period. However, shown by previous research (Bonnar et al., 2018), sleep can affect sport specific skill execution. Thun et al. (2013) reported a series of technical skills that improved in the evening for various sports. This included an increase in swimming velocity, improved accuracy of badminton serves, dribbling speed and chipping accuracy in football. However, no difference in technical skill was seen in my study due to the short distance.

There was a decrease in fatigue in the evening, compared to the morning ($P = 0.006$). Fatigue is also influenced by sleep, and the significant difference could be a result of a lack of sleep. A study by Grandner et al. (2020), looked at how sleep (duration and quality) and fatigue influenced mental health in student athletes. The results showed that the higher the PSQI scores, the higher the scores for depression and anxiety. A shorter sleep duration was also associated with higher levels of stress, anxiety and depression. The overall finding that sleep plays an important role in student athlete's mental health should be addressed more in practice. The National Collegiate Athletics Association (NCAA) included sleep screening as part of their published 'Mental Health Best Practices' guidelines, highlighting the importance of sleep quality and duration (Grandner et al., 2020).

Partial sleep deprivation has been studied, and results show that maximal measures of strength and single bouts of aerobic exercise are minimally affected (Bonnar et al., 2018). However, sports specific skill execution, submaximal exercise bouts, and muscular and anaerobic power are more affected by sleep deprivation (Bonnar et al., 2018). The results of the PSQI showed that eight out of the 11 (66%) had poor quality sleep, including one with a sleeping disorder. Therefore, it is more likely than not that the swimming performance of these participants were affected by poor quality sleep. As a result of the findings by Bonnar et al. (2018) sleep interventions have been studied to try to minimise these effects. These interventions can be categorised into sleep extension (and napping) and sleep hygiene. The results from a systematic review by Bonnar et al. (2018) show that improvements in sleep hygiene increase sleep duration but have no effect of performance. However, sleep extension was found to

improve sport- specific skill execution and cognitive related tasks such as reaction time (Bonnar et al., 2018).

There are a variety of limitations to this study including the small sample size (n= 11). It is hard to establish differences in sleep quality due to the small sample size, as there were three participants deemed to have good quality sleep and eight deemed to have poor quality sleep (including one with a sleeping disorder). Although the PSQI questionnaire is a valid measure of sleep quality, it is subjective, making it difficult to know the accuracy of the results. It would be necessary to examine sleep quality through a more objective and scientific measure, such as a polysomnography (PSG). However, this is expensive, time consuming, and unavailable to most people. Another option would be to record sleep using smart watches, however not all participants had access to this. Another improvement to be made would be recording sleep quality the night before the swims, as this was done as an overall assessment of their sleep. This study could also be improved by participants wearing a heart rate monitor and recording their heart rate at the end of each swim, to help improve the accuracy of RPE. Future research may be continued with a larger sample size to consolidate and add to the findings of this study. It could be improved using more scientific measures for sleep to confirm the results. It could also be repeated using different distances such as 100 m to see if the same results are found.

*Conclusion*

For distance events, swimming performance is found to be better in the evening rather than in the morning, but sprinting is not significantly impacted by the time of day. This should be taken into account when organising tournaments like Nationals, Championships, and British Universities and Colleges Sport (BUCS) events. It should also be considered when planning training sessions, as athletes will perform better at training in the evening. As a result, intense sprint training can be performed at any time of the day and long-distance aerobic exercise should be done in the evening. Although it is not a direct predictor of performance, sleep quality is still a major factor. It is a reliable indicator of performance, along with a host of other factors like alertness and fatigue. In order to optimise performance, student athletes should practice good sleep hygiene and maintain a regular sleep schedule. If further research on this topic was to be conducted, participants should wear smart watches to more accurately monitor their sleep and swims repeated at several times using different distances and events.

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## Research Article

# Effects of the conventional deadlift and Romanian deadlift on muscle activation and joint angles at a submaximal intensity

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## Abstract

In strength and conditioning, exercise selection and intensity are pivotal for designing resistance training programmes. The conventional deadlift (CD) and Romanian deadlift (RDL) are exercises targeting the lower limbs. Despite being similar, differences exist and comparative studies between CD and RDL remain scarce. This study (i) assessed if the biceps femoris (BF) exhibited greater activation during the RDL, and (ii) determined if the vastus lateralis (VL) and BF showed increased activation during the CD. Fifteen active adults participated in the study, with EMG sensors placed on the VL and BF and markers for 2D motion analysis in the sagittal plane. Maximal voluntary contraction (MVC) data were collected for both lifts at 70% of the RDL 1RM. Five repetitions at 50% of the RDL 1RM were tested for EMG and 2D motion analysis. Data were analysed using paired t-tests and Wilcoxon signed-rank tests. Results revealed higher VL activation in the CD ($P < 0.05$), with no significant difference in BF activation. No differences were observed in hip angles at mid-thigh and knee height ($P > 0.343$), but differences were noted at the bottom position. Knee angles differed significantly during ascent and descent at mid-thigh ($P < 0.027$), while ankle differences were evident at knee height and the bottom position ($P < 0.12$). Ranges of motion differed for all joints ($P < 0.002$). In conclusion, this study found no difference in BF activation but greater VL activation during the CD.

**Keywords:** deadlift, injury, joint angles, muscle activation, Romanian deadlift.

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# Introduction

Exercise selection and an appropriate loading stimulus over time are the cornerstones of an effective resistance training programme. Many tools can be implemented to achieve strength training goals for those delivering resistance training programmes, including the "Big 3": the squat, bench press and the conventional deadlift (CD). The CD is a compound exercise prescribed to increase the strength of the posterior chain muscles (gluteus, hamstrings, erector spinae) and the quadriceps (Parker, 2008). However, in sports like CrossFit, where high-intensity and fast-paced training is encouraged, the loss of form may increase the risk of injury due to increased stress on the lumbopelvic region. A systematic review by Alekseyev et al. (2020) found that within 12 months, 18% of CrossFit injuries occurred while performing a CD. Hexagonal deadlifts have been popularised due to the design of the barbell facilitating a shift of focus from the lower back, hips, and hamstrings to the quadriceps thus reducing the stress on the lumbopelvic region (Camara et al., 2016). The mixed-grip deadlift is another popular variant used in resistance training programmes, as grip strength is a limiting factor (Pratt et al., 2020). The Romanian deadlift (RDL) is a variant of the CD. Typically, athletes and gym-goers use the RDL to strengthen the hamstrings, paraspinal and gluteal muscles (Piper & Waller, 2001). In sports, the RDL helps to teach athletes the Olympic lifts (Frounfelter, 2000) and improves the hamstring-quadricep ratio (Veeck et al., 2023). The RDL is under-researched in favour of the CD; the movements are mechanically similar and often mistaken for one another (Lee et al., 2018).

Using electromyography (EMG) allows researchers to investigate muscle activation. Specifically, surface electromyography (sEMG) allows the researcher to collect data without discomfort or interference to the athlete. The most researched muscles during a CD are the biceps femoris (BF), gluteus maximus, vastus lateralis (VL), and erector spinae, with the CD and stiff-legged deadlift (SLD) being the most investigated variants of the deadlift (Martín-Fuentes et al., 2020).

Studies comparing the CD and RDL are limited; there is currently one study that directly compared the two (Lee et al., 2018). This research is important as it can help inform strength and conditioning coaches, athletes, and gym-goers of the potential benefits and injury risks associated with these lifts. This study will be the first to examine and compare VL activity directly between the CD and RDL. This study aims to compare the CD and RDL at submaximal intensity in recreational athletes. Using surface EMG on the VL and BF and 2D motion analysis of the lower limb, we aim to determine if (i) the BF activation is greater during the RDL and (ii) if there is a higher activation of both VL and BF during the CD.

# Methods

*Participants*

Fifteen recreationally active, healthy adults (11 males; 4 females; 25 ± 5 years; 1.75 ± 0.09 m; 80.4 ± 12.3 kg) volunteered to participate in this study. Participants were excluded if they experienced any musculoskeletal injuries within six months of participating. Inclusion criteria included 3 to 5 years of experience with the CD and RDL, and participants were asked not to partake in strenuous exercise two days before the experiment. All participants were provided with details of the experiment and the associated risks and completed a physical activity readiness questionnaire (PAR-Q) before providing informed consent. The study received ethical approval from the Northumbria University Faculty of Health and Life Science Ethics committee.

*Protocol*

After the participants' descriptive data (sex, stature, mass) were collected, they were allocated to groups 1 or 2, which changed the order in which the movements were performed to eliminate order bias. RDL 1RM was self-reported; if the participant did not know their 1RM, the Brzycki formula was used to predict it (predicted 1RM = w / (1.0278 – 0.0278x; w = weight lifted; x = number of repetitions performed). The Brzycki formula is valid when the number of repetitions is <10 (Brzycki, 1993). The load was rounded to the nearest 5 kg due to the lack of microweights. Figure 1 shows the protocol for the warm-up. Participants were asked to perform the warm-up and protocol barefoot, so shoe type did not influence the results. The warm-up included a mobility circuit consisting of five movements performed for 40 seconds, with a 20-second transition for one circuit. The barbell complex was performed with an empty standard barbell (20 kg) for five repetitions per movement and repeated for 2-3 sets with a 1-minute rest between sets. The barbell complex provided an opportunity to assess the participant's ability to perform the lifts correctly. The barbell load was progressively loaded to 70% 1RM of the RDL for a smooth transition to collect maximal voluntary contraction (MVC) data. The RDL 1RM value was chosen because a lower load is required for an RDL than a CD, as the relative intensity between the lifts differs.

Following the warm-up, MVC data was collected for the CD and RDL as 70% 1RM of the RDL to normalise EMG data. Next, the EMG and 2D video capture data were recorded for five repetitions using 50% of RDL 1RM for both CD and RDL. Participants were not coached to capture their typical technique during the test after evaluating their ability to perform the lifts during the warm-up.

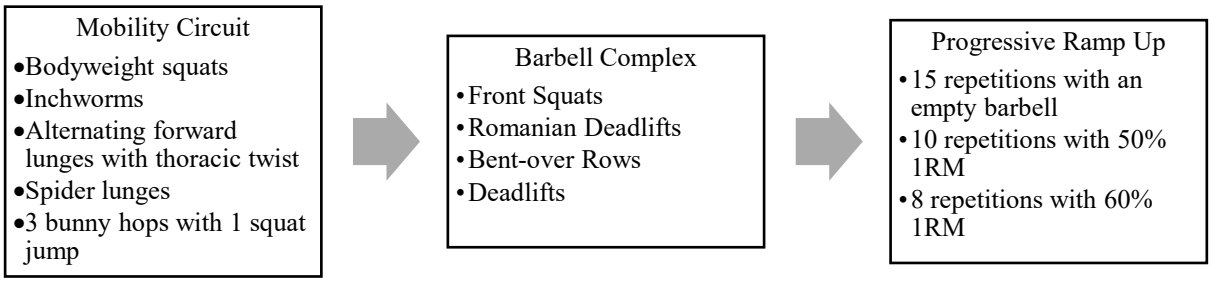


**Figure 1.** Warm-up protocol. Mobility circuit; 40 s work, 20 s transition, barbell complex; 3 sets of 5 repetitions per movement with an empty barbell with one-minute rest between sets, progressive ramp up; load calculated as % of RDL 1RM.

*Electromyography*

EMG analysis was performed using a wireless surface system (sEMG, Delsys Trigno Research+, Delsys Inc, Natick, MA, USA) at a sampling rate of 2,000 Hz. Before sensor placement, the participants' skin was prepared by shaving and cleaning the area with an alcohol wipe after the warm-up to reduce interference in the EMG recording. Wireless sEMG sensors were placed on the VL and BF of the dominant limb following SENIAM guidelines (Konrad, 2006). Adhesive tape was used to secure the sensors to the skin and reduce movement artefacts. This study did not include the erector spinae and gluteus maximus due to ethical considerations regarding privacy and crosstalk with other muscles was weak during pilot testing.

An amplitude analysis was conducted on the raw EMG data using EMGWorks (v4.8, Delsys Inc, Natick, MA, USA). A root mean squared (RMS) filter was applied to the raw data using a 0.125 s window length and a 0.0625 s window overlap. If needed, a high-pass filter was applied to remove movement artefacts. 70% MVC was used to normalise the data, and the mean of the peak RMS value from each repetition was used in statistical data analysis. EMG from one participant and VL data from another were excluded from the analysis due to corrupt data.

*2D Video Capture*

Five coloured markers were placed on the acromion process, greater trochanter, lateral epicondyle of the knee, and the 5$^{th}$ metatarsal of the participant's dominant side. A video camera (Sony, Handycam HDR-CX240) and tripod were set to the researcher's hip height and captured in the sagittal plane. The ascending and descending phases were split into the bottom position, knee height, and mid-thigh to simplify comparisons (see Figure 2). Angles from five repetitions at the hip, knee, and ankle at each phase and position were analysed using open-source video analysis software (Kinovea v0.9.5). Kinovea is valid and has good intra-rater reliability when measuring angles at the hip, knee, and ankle (Puig-Divi et al., 2019). One repetition was missing from the video data for the CD due to a counting error.

Hip angles were measured relative to the acromion process and the lateral epicondyle of the femur; knee angles were measured relative to the greater trochanter of the femur and the lateral malleolus of the ankle; ankle angles were measured relative to the lateral epicondyle of the femur and the 5th metatarsal of the foot. All angles were measured in the sagittal plane, with 180° representing a full extension of the hip and knee and 90° representing a neutral foot position. The mean of five repetitions for each variable was used in the statistical analysis. The ROM for each joint was calculated by the difference between the bottom and mid-thigh positions for each phase.

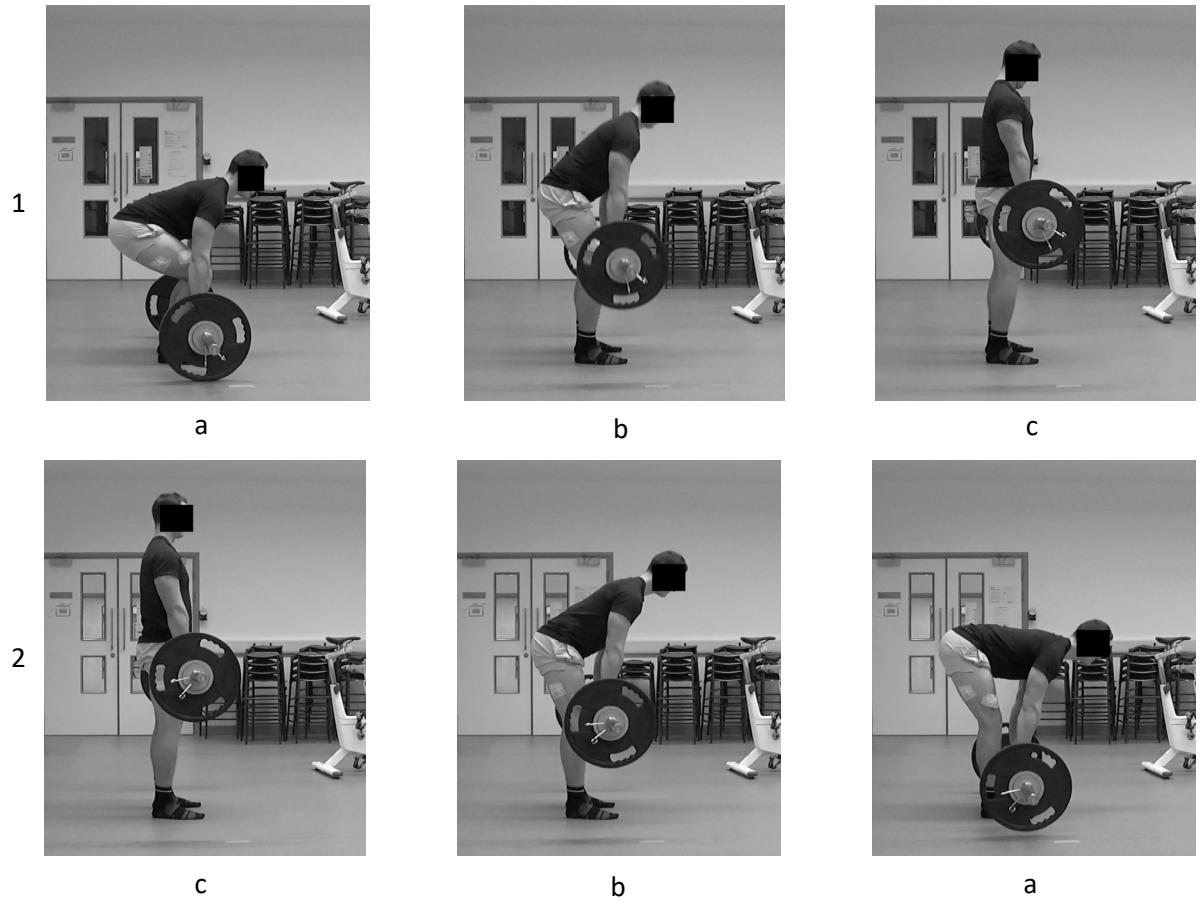


**Figure 2.** Positions for the CD and RDL: 1 = conventional deadlift; 2 = Romanian deadlift; a = bottom position; b = knee height; c = mid-thigh.

*Data Analysis*

For this within-subject design, paired t-tests were conducted to compare electromyographic variables (VL and BF) and the ascending and descending phases for joint angles and ROM at the hip, knee, and ankle for the CD and RDL. Before running the paired t-test, statistical assumptions were checked for normality using the Shapiro-Wilk test. Where statistical assumptions were violated (n = 3), a non-parametric test was conducted using a Wilcoxon signed-rank test. All statistical tests were performed

using IBM SPSS Statistics (v28 Armonk, NY, USA) with the level of significance set at $p < 0.05$ for all tests.

## Results

*Electromyography*

Table 1 shows the results for EMG activity. The results suggest greater activation of the VL in the CD (87.5 ± 26.1 vs 59.2 ± 24.7%; $P < 0.001$). However, there was no difference in the BF between the CD and RDL (65.9 ± 23.4 vs 77.9 ± 33.2%; $P = 0.244$).

**Table 1**. EMG results from the vastus lateralis and biceps femoris.

| | Mean (SD) | | | | | |
|---|---|---|---|---|---|---|
| | Conventional Deadlift | Romanian Deadlift | Mean Diff | *t* | *df* | *P* |
| Vastus Lateralis (%) | 87.5 (26.1) | 59.2 (24.7) | -28.3 | 7.331 | 12 | 0.001* |
| Biceps Femoris (%) | 65.9 (23.4) | 77.9 (33.2) | 12.0 | -1.220 | 13 | 0.244 |

Note: Mean and SD expressed as a percentage of 70% MVC. * Denotes statistical significance between CD and RDL; $P < 0.05$.

*Joint Angles and Range of Motion*

Angles at the hip (see Table 2) suggest no difference at mid-thigh between the CD and RDL whilst ascending or descending (ascent; 173.3 ± 5.6 vs 172.2 ± 5.9°, descent; 173.3 ± 5.6 vs 171.8 ± 5.8°, $P \geq 0.343$). Furthermore, there were no differences in knee height whilst ascending or descending (ascent; 113.0 ± 6.2 vs 112.9 ± 5.3°, descent; 114.4 ± 6.0 vs 114.6 ± 5.2°, $P \geq 0.892$). Angles at the bottom position, for both ascending and descending phases were different (ascent; 54.5 ± 6.4 vs 64.6 ± 8.6°; $P = 0.002$; descent; 54.4 ± 6.9 vs 64.6 ± 8.9°; $P = 0.002$).

Angles at the knee (Table 3) suggest a difference between ascending and descending at mid-thigh (ascent; 173.9 ± 6.5 vs 170.9 ± 6.8°, descent; 173.5 ± 6.7 vs 170.3 ± 6.9°, $P < 0.027$) and bottom positions (ascent; 107.1 ± 13.6 vs 137.3 ± 9.4°, descent; 111.8 ± 16.3 vs 137.3 ± 9.4°, $P < 0.001$). There was no difference between ascending and descending at knee height (ascent; 154.7 ± 5.0 vs 156.9 ± 5.2°, descent; 154.7 ± 4.9 vs 157.4 ± 5.2°, $p > 0.056$).

**Table 2.** Hip angles between the CD and RDL.

| | | Mean (SD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Conventional Deadlift | Romanian Deadlift | Mean Diff | *t* | *df* | *P* |
| Mid-thigh (°) | Ascent | 173.3 (5.6) | 172.2 (5.9) | -1.2 | 0.435 | 14 | 0.670 |
| | Descent | 173.3 (5.6) | 171.8 (5.8) | -1.5 | 0.982 | 14 | 0.343 |
| Knee Height (°) | Ascent | 113.0 (6.2) | 112.9 (5.3) | -0.1 | 0.028 | 14 | 0.978 |
| | Descent | 114.4 (6.0) | 114.6 (5.2) | 0.2 | 0.982 | 14 | 0.892 |
| Bottom Position (°) | Ascent | 54.5 (6.4) | 64.6 (8.9) | 10.1 | 115 | - | 0.002*[a] |
| | Descent | 54.4 (6.9) | 64.6 (8.9) | 10.3 | -3.957 | 14 | 0.001* |

Note: * Denotes statistical significance between CD and RDL; P < 0.05. [a] Denotes data not normally distributed and analysed with Wilcoxon signed-rank test.

**Table 3.** Knee angles between the CD and RDL.

| | | Mean (SD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Conventional Deadlift | Romanian Deadlift | Mean Diff | *t* | *df* | *P* |
| Mid-thigh (°) | Ascent | 173.9 (6.5) | 170.9 (6.8) | -3.0 | 18 | - | 0.017* [a] |
| | Descent | 173.5 (6.7) | 170.3 (6.9) | -3.1 | 21 | - | 0.027* [a] |
| Knee Height (°) | Ascent | 154.7 (5.0) | 156.9 (5.2) | 2.2 | -1.067 | 14 | 0.169 |
| | Descent | 154.7 (4.9) | 157.4 (5.2) | 2.8 | -2.085 | 14 | 0.056 |
| Bottom Position (°) | Ascent | 107.1 (13.6) | 137.3 (9.4) | 30.2 | -7.646 | 14 | 0.001* |
| | Descent | 111.8 (16.3) | 137.3 (9.4) | 25.5 | -5.540 | 14 | 0.001* |

Note: * Denotes statistical significance between CD and RDL; P < 0.05. [a] Denotes data not normally distributed and analysed with Wilcoxon signed-rank test.

Angles at the ankle (see Table 4) showed no difference with ascending or descending between CD and RDL at mid-thigh (ascending; 112.9 ± 8.5 vs 112.7 ± 8.1°, descending; 113.6 ± 8.4 vs 112.6 ± 8.3°, P > 0.493). There were differences between the CD and RDL for ascending (111.4 ± 6.9 vs 115.2 ± 6.5°, P = 0.002) and descending (112.6 ± 6.6 vs 115.6 ± 6.9°, P = 0.012) at knee height. Furthermore, differences were found for ascending (96.5 ± 8.8 vs 110.8 ± 9.6°, P = 0.001) and descending (97.9 ± 10.2 vs 110 ± 8.1°, P = 0.001) at the bottom position.

Differences for ROM were consistent (see Table 5); ROM at the hip (ascent; 117.8 ± 11.1 vs 107.7 ± 8.9°, P = 0.002, descent; 118.1 ± 12.1 vs 107.2 ± 8.6°, P = 0.001), knee (ascent; 65.2 ± 13.9 vs 38.3 ± 14.5°, P = 0.001, descent; 60.0 ± 12.6 vs 37.8 ± 14.3°, P = 0.001), and ankle (ascent; 15.3 ± 5.9 vs 5.9 ± 6.1°, P = 0.002, descent; 15.2 ± 6.7 vs 6.3 ± 6.3°, P = 0.001).

**Table 4.** Ankle angles between the CD and RDL.

| | | Mean (SD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Conventional Deadlift | Romanian Deadlift | Mean Diff | *t* | *df* | *P* |
| Mid-thigh (°) | Ascent | 112.9 (8.5) | 112.7 (8.1) | -0.2 | 0.199 | 14 | 0.845 |
| | Descent | 113.6 (8.4) | 112.6 (8.3) | -0.9 | 0.704 | 14 | 0.493 |
| Knee Height (°) | Ascent | 111.4 (6.9) | 112.9 (8.3) | 3.8 | -3.866 | 14 | 0.002* |
| | Descent | 112.6 (6.6) | 115.8 (6.9) | 3.0 | -2.903 | 14 | 0.012* |
| Bottom Position (°) | Ascent | 96.5 (8.8) | 110.8 (9.6) | 14.3 | 115.000 | - | 0.002*[a] |
| | Descent | 97.9 (10.2) | 110.0 (8.1) | 12.0 | -4.043 | 14 | 0.001* |

Note: * Denotes statistical significance between CD and RDL; $p < 0.05$. [a] Denotes data not normally distributed and analysed with Wilcoxon signed-rank test.

**Table 5.** Range of motion at the hip, knee, and ankle.

| | | Mean (SD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Conventional Deadlift | Romanian Deadlift | Mean Diff | *t* | *df* | *P* |
| Hip (°) | Ascent | 118.8 (8.8) | 107.5 (10.8) | -11.3 | 3.789 | 14 | 0.002* |
| | Descent | 119.0 (9.3) | 107.2 (10.6) | -11.8 | 4.194 | 14 | 0.001* |
| Knee (°) | Ascent | 66.8 (13.9) | 33.6 (12.8) | -33.2 | 8.637 | 14 | 0.001* |
| | Descent | 61.7 (15.4) | 33.0 (12.7) | -28.6 | 6.239 | 14 | 0.001* |
| Ankle (°) | Ascent | 16.4 (7.1) | 2.5 (7.4) | -14.0 | 5.612 | 14 | 0.001* |
| | Descent | 15.6 (8.7) | 3.4 (6.8) | -12.2 | 3.996 | 14 | 0.001* |

Note: * Denotes statistical significance between CD and RDL; P < 0.05.

## Discussion

This study aimed to determine (i) if there is a difference in the BF between the CD and RDL, (ii) if there was greater activation of the VL and BF in the CD, and (iii) if an injury was more likely to occur in the CD or RDL using joint angles and ROM of the hip, knee, and ankle. The key findings of this current study are as follows: 1) There were no differences in BF activation between the CD and RDL. 2) Activation of the VL during the CD differed from the RDL and 3) ROM at the hip, knee, and ankle during the CD was greater than the RDL.

*Electromyography*

Firstly, the RDL is a popular movement to train the hamstrings; however, our findings agree with those of Lee et al. (2018), who found no difference in BF activation between the CD and RDL. Positioning of the hip has been shown to influence the ROM at the knee and increase the moment arm of the BF (Hamill et al., 2022). The BF activity could be due to the length-tension relationship being influenced by the interaction between the hip and knee positioning. Furthermore, Bezerra et al. (2013) suggest this result could be due to the hamstrings acting as knee stabilisers during the RDL and the SLD. Conversely, it has been suggested that the hamstrings generate the greatest force when flexed at 90°, reducing by 50% when reaching full extension (Hamill et al., 2022). The differences in knee ROM

between the CD and RDL (ascent = 67 vs 34°; descent = 62 vs 33°) suggest more time under tension, which could explain why BF activity during the CD was not different. Moreira et al. (2023) report similar results whereby the BF is highly activated at knee height during the CD. Due to the lack of EMG data comparing the CD and RDL, findings by Coratella et al. (2022) were included, who found no difference in BF activation between the RDL and SLD, so they could reasonably be used for comparisons with the CD.

Secondly, this study is the first to compare VL activity between the CD and RDL, making direct comparisons between studies impossible. Lee et al. (2018) compared EMG activity for the rectus femoris between the CD and RDL. Although it is a quadricep muscle, it is a biarticular muscle with attachments at the hip and knee, unlike the VL, whose attachments are at the greater trochanter and the knee, potentially inflating EMG activity. VL results agree with Bezerra et al. (2013), who compared the CD with the SLD and found VL activation peaked within the first 20° during the ascent of a CD. Interestingly, Koderi et al. (2020) studied the differences in BF and VL activation during the RDL with different stance widths. BF activation did not change; however, with a wide stance, VL activity increased. This could be attributed to a change in knee angles for the different stance widths.

*Joint Angles and Range of Motion*

Joint angles at the mid-thigh position during ascent and descent showed no significant difference at the hip or ankle. This finding is not surprising, as the hip should be close to full extension and the ankle in a neutral position. However, the knee angle was significantly different. This could be due to the participants anticipating the hip flexion for the RDL before the lift was completed. The descent during the RDL is initiated by hip flexion, while knee flexion is limited between mid-thigh and knee height positions compared to the CD (13 vs 19°).

Angles at knee height showed no difference at the hip and knee. This study's findings are similar to those of Piper and Waller (2001), Lee et al. (2018), and McAllister et al. (2014), who observed knee flexion between 15 to 30° for the RDL. Unlike the previous studies, this study did not standardise technique, stance width or knee angle; however, standardisation was implemented by asking lifters to perform the lifts barefoot. Although footwear has been found not to improve performance, it has been shown to manipulate joint angles and ground reaction force (La Marche, 2019; Valenzuela et al., 2021). There was a significant difference at the ankle, with the CD showing greater angles during ascent and descent. The RDL's starting position is at the mid-thigh and descends to the bottom position; depending on the individual's hamstring flexibility, the ankle may not need to dorsiflex following the

knee height position. In the CD (during the ascent), to allow a vertical bar path and avoid horizontal displacement of the bar, the shank needs to plantarflex.

Angles at the bottom position for the hip, knee, and ankle differed significantly. The significant differences in knee angle at the bottom position during the descent agree with Lee et al. (2019), who suggest that the difference in knee flexion during the RDL at the bottom position could be due to the lack of flexibility of the hamstrings. However, the previous study only studied flexion angles during the CD and RDL. Escamilla et al. (2000) also reported knee angles greater than the hip angle during the CD at the bottom position, suggesting the hips will be above the knees at the start of the CD and significantly different from the RDL in this current study. When studying muscle forces during the CD, Schellenberg et al. (2017) reported a ROM of 70 to 100° of knee flexion is required for the optimal activation of the VL. The findings of this current study from the ascending phase were very close to this study's observation (65°). Furthermore, the smaller knee ROM and lower VL activation of the RDL are consistent with the previous study, which compared the CD to the good morning (a movement mechanically similar to the RDL).

*Limitations*

This study had several limitations. Due to the confines of 2D motion capture in the sagittal plane, weight plates and loose clothing obscured or moved the coloured markers placed on the participants at mid-thigh and knee height positions. Therefore, guidelines were drawn on the video to estimate the anatomical landmarks and improve reliability. Furthermore, 3D motion capture is the gold standard method of collecting kinematic data and may have provided more accurate and reliable data, but the set-up may have been a burden to the participants. EMG has its own set of limitations. SENIAM guidelines were followed to reduce the cross-talk between muscles. Participants were shaved, and adhesive tape was applied after the warm-up to secure the sensors to the skin. However, some data contained questionable signals, possibly due to movement artefacts induced by weight plates hitting the floor. Noise signals due to electrical equipment could not be avoided and may have influenced data. Although measuring the 1RM for the RDL may have been more reliable, the Brzycki formula was used to estimate 1RM values to minimise the risk of injury to participants who may have never tested their 1RM before (Brzycki, 1993). This current study investigated the lifts in the sagittal plane, limiting the investigation of potential knee injuries, such as those involving knee valgus.

*Future Directions*

Future research could explore additional muscles and joints in the lower and upper extremities, such as the paraspinal, gluteal, and forearm muscles. Additionally, comparing the grip types between the lifts may be of interest. Furthermore, a consistent EMG normalisation method across the research would also be beneficial. The different methods make comparing findings in the research challenging. 3D motion analysis in conjunction with sEMG could provide more insight into muscle activity and intermuscular coordination during different phases of the lifts. Additionally, tracking the bar path during the lifts could help inform lifters of the impact on muscle activation and risk of injury.

*Conclusion*

Firstly, the CD and RDL are effective movements for training the BF. This study's protocol was based on the RDL 1RM; however, the RDL elicited some differences in the EMG response and may be a better option if the lifter aims to improve their hamstrings-quadriceps ratio without adding the back squat. Finally, although the CD may be more beneficial for concurrently training the VL and BF, neuromuscular fatigue may occur quicker than during the RDL with the same load. This research has highlighted the difference between VL activity between the CD and RDL. Strength and conditioning coaches and recreational athletes could use the CD when adequately recovered, and increasing strength or rehabilitating the knee is the goal.

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## Research Article

# The acute effects of Home Advantage on English Professional Rugby Union

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## Abstract

This study comprehensively explores the acute effects of home advantage (HA) in English professional Rugby Union, focusing on performance metrics that extend beyond winning percentages. The results reveal that home teams won 69% of their matches, with a higher try scoring rate (t = 3.39, P <0.001, ES = 0.44; home team scoring 3.36 ± 1.85 vs. the away team 2.61 ± 1.5). The home team (1.17 ± 0.11 m) also exhibiting superior ground gained per carry than the away team (1.05 ± 0.10 m, t = 2.48, P = 0.001, ES = 0.42). Moreover, the findings indicate that away teams (1.10 ± 1.04) were more prone to injuries than home teams (0.51 ± 0.64) during the early part of the season (t = −3.06, P = 0.003, ES = 0.68), suggesting a potential link between travel fatigue and physical strain. When attacking, away teams faced a higher frequency of penalties per game (3.77 ± 2.14) compared to the home team (3.24 ± 1.80, t = −2.10, P = 0.037, ES = 0.27), complicating the away team's ability to mount effective scoring opportunities. These findings suggest that HA not only influences match outcomes but also significantly impacts key in-game behaviours, such as try-scoring efficiency and defensive performance. This research provides valuable insights for coaches and players, emphasizing the need to adapt strategies for both home and away games to account for the unique advantages and disadvantages associated with HA. Future research should examine these effects across multiple seasons and competitions to deepen our understanding of the complexities surrounding home advantage in Rugby Union.

**Keywords:** injury, performance analysis, sports performance, tackle completion, try-scoring.

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## Introduction

Home Advantage (HA) is the given nomenclature for the phenomenon of 'home' competitors having increased success compared to their 'away' counterparts (Courneya & Carron, 1992; Carron et al. 2005; Jamieson, 2010). HA can be observed in individual or team sports (Jamieson, 2010) and is not exclusive to sports; it is also seen in politics, business, and warfare (Edwards, & Archambault, 1979; Devine & Kopko, 2013). Research on HA heavily focuses on the source/s of the phenomenon, this research has spanned a vast variety of sports, locations and competitions (Jamieson, 2010). Courneya and Carron (1992), produced a conceptual model of HA's major components: game location, game location factors, critical psychological states, critical behavioural states, and performance outcome.

Fans are thought to be a key influence on HA. The Covid-19 pandemic provided natural evidence of how teams perform with fans absent; during this time HA noticeably decreased, occasionally HA was nullified completely (Wang & Qin, 2023). Technical skills such as goals, shots or shots on targets were negatively impacted for the home team, whilst the away team experienced the opposite effect (Wang & Qin, 2023; Bhagwandeen et al., 2024). Physical capabilities do not seem to be affected by HA (Wang & Qin, 2023). Indoor sports show an increased HA, due to a more tangible crowd presence (Pollard, 2017). As many sports have ventured further into professional, they have seen the impact of travel and familiarity on HA decrease (Pollard, 1986; Jamieson, 2010). Whilst both are key impacts on HA, the magnitude of their impact has decreased with more efficient travel methods and preparation, as well as less variability in pitch dimensions, surface quality, etc. (Jamieson, 2010; Beckmann, 2022). This is one of the causes of lower leagues experiencing increased HA, having poorer travel and more standardisation (Leite & Pollard, 2018). Parallels in the unfamiliarity with terrain and conditions can be drawn to asymmetric warfare tactics such as the Vietnam conflict, an example of HA outside of sports (Buffaloe, 2006).

Global Travel being easier allows for increased away fan attendance (Beckmann, 2022). Most of the components of HA directly strengthen the home team, travel is a distinct negative effect on the away team (Lee & Galvez, 2012; Edwards & Archambault, 2012; Leatherwood & Dragoo, 2013; Huyghe et al., 2018). The modality and length of travel change the type of stress that they experience, therefore showing differing performance decrements (Hands et al., 2023). Nutrition, recovery and access to facilities are all impacted by travel (Leatherwood & Dragoo, 2013; Huyghe et al., 2018; Losak & Sabel, 2021). Whilst all travel modalities increase injury risk and travel fatigue, international travel is especially damaging on the athlete's circadian rhythm (Leatherwood & Dragoo, 2013; Huyghe et al., 2018; Losak & Sabel, 2021). With the travel and fixture demands of many elite sports, it can be

impossible for athletes to have a healthy in-season circadian rhythm (Leatherwood & Dragoo, 2013; Huyghe et al., 2018; Leota et al., 2022)

Ritualised, “must win” and high-stakes matches show an increased magnitude of HA due to increased crowd activity and pressure to perform (Ward, 1998; Jamieson, 2010). In sports with more games, HA is dampened due to the individual importance and pressure of each match being comparatively less (Jamieson, 2010). Territorialism increases the pressure, as can be seen in derbies or rivalry games where both fan, player and officiating activity is affected, increasing HA (Edwards & Archambault, 2012; Sors et al., 2019; Islam et al., 2021). Trending decrease in HA may be a consequence of declining testosterone levels, aggression, and violence (Batrinos, 2012; Beckman, 2022).

Higher degrees of officiating subjectivity increase the magnitude of HA (Balmer et al., 2001; Raab et al., 2021). Highly objective sports such as track and field events, show decreased or a complete absence of HA (Balmer et al., 2001). Referees are not immune to HA, showing a natural inclination to favouring the home competitors especially with penalisation (Edwards & Archambault, 2012; Areni, 2014; Wang & Qin, 2023; Bhagwandeen et al., 2024). Jamieson (2010) finds home teams win 60% of games across various sports (0.60 ± 0.07), with sport-specific differences. This aligns with Gómez et al. (2011) and Pollard et al. (2017), who note Rugby's high HA. Gómez et al. (2011) report a 67% HA in a Spanish rugby (2005–2010; 67.00 ± 3.84) and include HA data from France (73.4%), Italy (66.2%), and England (65.9%). France’s increased HA may be due to stronger fan activity than other Rugby cultures. HA is most prominent in close-quarters, contact sports with minimal stoppage in play like Rugby (Pollard et al., 2017).

This study uniquely examined HA in Rugby Union, focusing on in-game effects rather than broad outcomes like winning percentages (Jamieson, 2010; Pollard et al., 2017). Unlike prior research, it analyses 119 matches from the 2022-2023 season, exploring metrics such as try-scoring, tackle completion, carrying efficiency, and injury patterns to understand HA's impact on match dynamics. Addressing gaps noted by Du Preez and Lambert (2007), it investigates acute performance changes caused by HA, offering actionable insights for players, coaches, and teams to enhance strategies (Courneya & Carron, 1992; Nevill & Holder, 1999).

## Methods

*Participants*

The dataset comprises all matches from the 2022-23 season of the Gallagher Premiership, within which 12 teams competed amongst each other. The data was obtained via one of these teams and all performances for each team are included. Two of the teams did not compete for the full duration of the season. These team's performances remained within the dataset although were removed when looking at per team values rather than league-wide calculations. This exclusion was done as the teams did not have an acceptable number of games played to account for anomalous performances.

Whilst it would have been preferable to analyse multiple seasons, previous years were impacted by Covid-19, thus providing a poor reflection of a standard season and the performances that can be found within it. Within the dataset, all 561 players were competed in the season and their performances were accounted for within the analysis. All players were male. The dataset does not contain player age, mass, stature or other such characteristics. Within the season the oldest player was 39 whilst the youngest was 18 years. Additionally, 43 different officials were involved in the season and therefore the dataset, whether it be as a lead referee, assistant referee or Television Match Official. Two of the 43 officials were female and matches were played across 17 different venues.

The Northumbria University Ethics Board granted ethical approval for this study. The data used within the research was obtained via a third-party data provider which services accurate match statistics to professional Rugby Union teams globally. All teams and individuals within the data have consented to the data provider for their performance data to be collected in such a manner, and to be used to the discretion of their clients.

*Measures*

The data was received in numerous event-based formats for each match, an individual file for each match. In chronological order, the events of the match were listed with necessary detail included, such as the event itself, the in-game time, the current score, the player and team responsible, etc. This format gives a detailed account for each event within the game and allows for a quantitative and qualitative review of the in-game performances. The units varied dependent upon the event that was being categorised, distance (such as carry or kick metres) used metres as their unit, time variables (such as ruck speed) is measured in seconds, percentage were used for qualitative measure such as tackle completion percentage, dominant tackle percentage, etc. Other metrics are simply frequency of the event i.e. tackles or passes.

*Procedures*

As the data was sourced from a professional performance data provider, the procedures were not done by the researchers themselves. The data is obtained via live match analysis/ data entry and is rigorously validated prior to being distributed to clients. The data is collected in chronological order of events. The detail of each event including information such as current score, team responsible, player, responsible, event action, event detail (tackle dominance, kick outcome, etc.), coordinates, among other information.

*Analysis*

The data was received in an event-based format, processed to attribute and total the statistics such as tackles, carries or penalties conceded for each match, for both the home and away team. This giving a reflection of each team's statistical performance. The dataset that that was generated from the processing of the original sequential event-based dataset holds over 95 data points for each team for all 119 matches within the 2022-23 season. An additional three datasets were created by sectioning the full season dataset into approximate tertiles that reflect the early, mid, and late stages of the season. The tertiles were manually chosen, using in-season breaks that were approximate thirds into the season, to present the chosen segment. Playoff matches were excluded from the late season and were not given their own section due to small number of matches. There would be merit to studying the changes of HA in playoff games but it is not suitable with the given data.

With a performance profile for the home and away team in each match prepared, a descriptive analysis of each event type was conducted, providing a mean and standard deviation for the aspects of a rugby union team performance. Following this, an independent two sample t-test was performed on each given statistic across the season. This test providing an indication of each aspect of the game show the most significant differences between the away and home team. Effect size (ES) was calculated concurrently to further quantify the magnitude of significance between the values. Cohen's D was the chosen effect size method. Significance was accepted as a P value less than 0.05. The same t-test procedures were followed for the early, mid, and late season datasets.

## Results

Overview

The home team won 82 of a possible 119 games, providing a league wide winning percentage of 69%. The mean for each team's home winning percentage was 64% (0.64 ± 0.27), greater than that observed for the away team winning percentage (0.30 ± 0.17; t = 3.80, P <0.001). The most significant difference presented by the analysis was tries scored (t = 3.39, P <0.001, ES = 0.44), wherein the home team scored a greater number of tries compared to the away team (3.36 ± 1.85 vs. 2.61 ± 1.54). The mean difference between home and away winning percentage was approximately 40%. The analysis looked at the home winning percentage under each referee (excluding those with less than 6 matches). This analysis provided a mean of 68% (± 11%). The same process was applied to the Television Match Official (TMO), showing less variance than the referees but a clear HA present (0.68 ± 0.09).

*Scoring*

The home team scored significantly more tries (3.36 ± 0.85), than the away team (2.61 ± 1.41; t = 3.39, P = 0.001, ES = 0.44). No other scoring aspects showed a difference between the teams throughout a full season, although there were increases for the home team (see Table 1). No difference of tries scored in the early season (t = 0.32, P = 0.750) but a difference was observed for mid (P = 0.002), and late-season (P = 0.004) season (see Figure 1). No other aspects of scoring in Rugby Union were significant when the season is segmented.

*Tackling*

None of tackling metrics have a difference although a notable effect size can be observed in certain metrics. Despite not being significant (P = 0.060), the tackles missed has a small effect size (ES = 0.34), as does the tackle completion (ES = 0.36), which is also not different (P = 0.10). No significance is observed when the season is segmented.

*Carrying*

When the home team attacked, they made more amount of ground for each carry (t = 2.48, P = 0.001, ES = 0.42), where the home team made 5.63 metres per carry (± 1.17 m) compared to the 5.16 m (± 1.05) which the away team gained. Although only metres per carry was different, line breaks (ES = 0.32) and defenders beaten (ES = 0.34) both have small effect sizes. The home team breaks the line 5.74 times per game (± 3.20) whilst the away team does so 4.81 times (± 2.58). Defenders beaten per match for the home team is 20.14 (± 7.28) and the away team is 17.83 (± 6.51). As seen in Figure 2, the home team has the edge is carry quality. Carries that fail to cross the gain line did not differ

between the home team (0.38 ± 0.07) to the away team (0.39 ± 0.07) with a small effect size (ES = 0.21).

**Table 1.** The effect of Home Field Advantage on Scoring events per game throughout a full season (mean ± SD).

| Event | Home | Away | t | Effect size |
|---|---|---|---|---|
| Tries** | 3.36 ± 1.85 | 2.61 ± 1.54 | 3.39 | 0.44 |
| Conversions made | 2.54 ± 1.50 | 2.40 ± 1.52 | 0.69 | 0.09 |
| Conversion attempts | 3.4 ± 1.62 | 3.28 ± 1.28 | 0.71 | 0.09 |
| Conversion completion % | 73 ± 29 | 72 ± 23 | 0.36 | 0.05 |
| Penalties made | 1.27 ± 1.15 | 1.16 ± 1.32 | 0.68 | 0.09 |
| Penalty attempt | 1.56 ± 1.34 | 1.30 ± 1.42 | 1.46 | 0.19 |
| Penalty completion % | 60 ± 44 | 57 ± 47 | 0.60 | 0.08 |
| Penalty tries | 15 ± 50 | 09 ± 37 | 1.04 | 0.14 |

** P < 0.001.

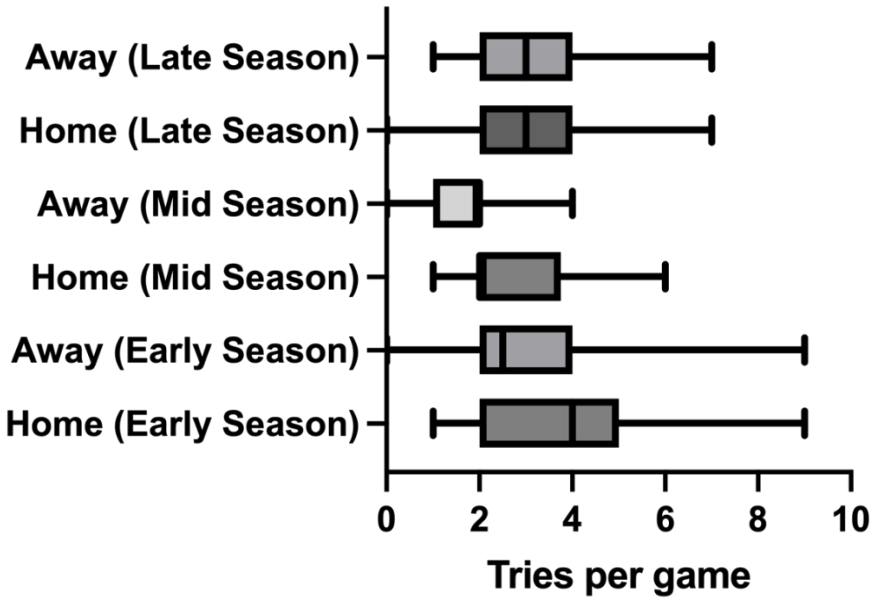


**Figure 1.** Try scoring throughout the season.

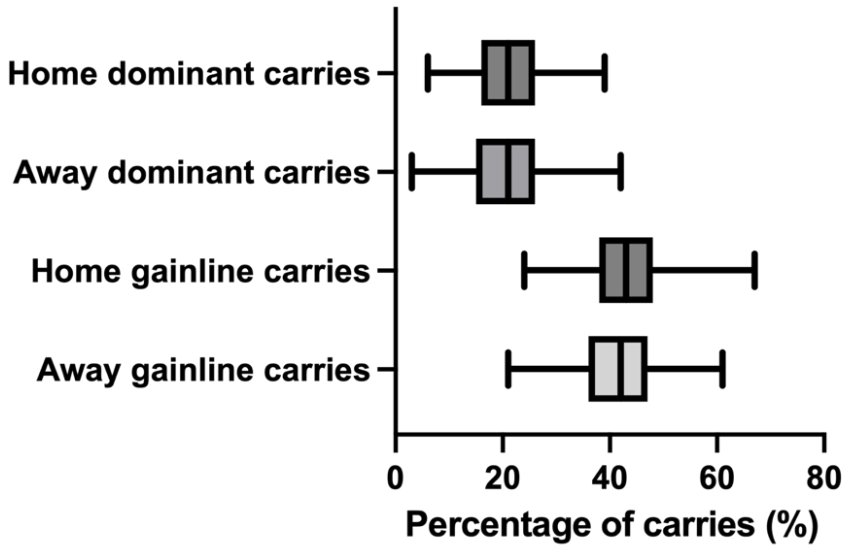


**Figure 2.** Carry quality throughout the season

*Injuries*

Whilst injuries are not different between the teams throughout the full season, when the season is segmented into approximate thirds representing early, mid, and late season, the away team is more likely to get injured (1.10 ± 1.04) than home teams (0.51 ± 0.64) in the early season (t = −3.06, P = 0.003, ES = 0.68, Figure 3. This difference is not seen for head injuries (t = 0.13, P = 0.900, ES = 0.02).

*Officiating*

Whilst total penalties did not differ throughout a full season, the effect size can be noted as being small (ES = 0.21). However, total penalties conceded was different in the late season (t = −2.19, P = 0.031) where the away team conceded more than the home team (12.19 ± 3.12 vs. 10.71 ± 3.05). When the away team was attacking, they are more likely to be penalised (t = −2.10, P = 0.037). The only area of advantages that hold a difference are advantages that end in a scrum being awarded, which the away team is more likely to experience (t = −2.10, P = 0.036, ES = 0.28).

*Errors*

None of the numerous error events showed between the teams when looking at the full season, nor were any effect sizes large (see Table 5). Passing errors become different in the later third of the season, the home team make more errors (t = 2.11, P = 0.038).

*Set piece*

There is no difference throughout any of the lineout or scrum events at any point of the season, although there is a small effect size (ES = 0.21) for scrum win percentage, in which the home team wins 88% (0.88 ± 0.16) and the away team wins 85% (0.85 ± 0.19).

**Table 2.** The effect of Home Field Advantage on Tackling events per game throughout a full season (mean ± SD).

| Event | Home | Away | t | Effect size |
|---|---|---|---|---|
| Tackles made | 146.26 ± 36.34 | 147.79 ± 39.19 | -0.31 | 0.04 |
| Tackles missed | 17.79 ± 6.50 | 20.12 ± 7.29 | -2.60 | 0.34 |
| Tackle attempts | 164.05 ± 40.26 | 167.91 ± 43.92 | -0.70 | 0.09 |
| Tackle completion % | 89 ± 3 | 88 ± 3 | 2.80 | 0.36 |
| Dominant tackles | 8.41 ± 5.39 | 8.57 ± 5.25 | -0.23 | 0.03 |
| Dominant tackle % | 5 ± 3 | 5 ± 3 | -0.230 | 0.01 |
| Non-dominant tackles | 41.55 ± 18.378 | 44.87 ± 16.305 | -1.474 | 0.19 |
| Non-dominant tackle % | 25 ± 9 | 27 ± 8 | -1.559 | 0.20 |

**Table 3.** The effect of Home Field Advantage on Carrying events per game throughout a full season (mean ± SD).

| Event | Home | Away | t | Effect size |
|---|---|---|---|---|
| Carries | 114.36 ± 27.82 | 113.04 ± 25.58 | 0.38 | 0.049 |
| Line Breaks | 5.74 ± 3.20 | 4.81 ± 2.58 | 2.48 | 0.32 |
| Defenders Beaten | 20.14 ± 7.28 | 17.83 ± 6.51 | 2.58 | 0.34 |
| Metres per carry* | 5.63 ± 1.17 | 5.1587 ± 1.05 | 3.27 | 0.42 |
| Post Contact Metres per carry | 2.52 ± .40 | 2.4674 ± .44 | 0.91 | 0.12 |

* $P < 0.05$

**Table 4.** The effect of Home Field Advantage on officiating events per game throughout a full season (mean ± SD).

| Event | Home | Away | t | Effect size |
|---|---|---|---|---|
| Ruck penalties | 4.64 ± 2.04 | 4.76 ± 2.14 | -0.43 | 0.06 |
| Maul penalties | 0.91 ± 1.03 | 1.03 ± 1.23 | -0.86 | 0.11 |
| Offside penalties | 1.24 ± 1.28 | 1.45 ± 1.29 | -1.31 | 0.16 |
| Foul play penalties | 1.45 ± 1.29 | 1.58 ± 1.49 | -0.70 | 0.09 |
| Scrum penalties | 2.51 ± 1.75 | 2.64 ± 1.75 | -0.56 | 0.07 |
| Lineout penalties | 0.48 ± 0.69 | 0.47 ± 0.61 | 0.1 | 0.01 |
| Advantages | 5.45 ± 2.91 | 5.13 ± 2.67 | 0.86 | 0.11 |

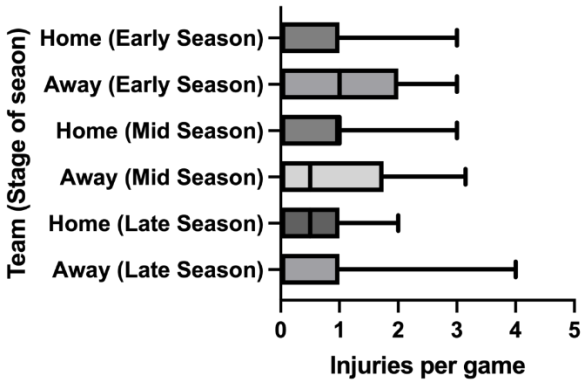


**Figure 3.** Injuries throughout the season

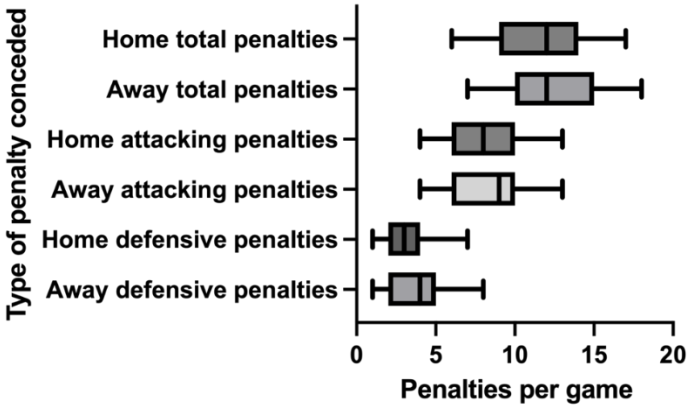


**Figure 4.** Penalties conceded under the effects of Home Advantage

**Table 5.** The effect of Home Field Advantage on player error events per game throughout a full season (mean ± SD).

| Event | Home | Away | t | Effect size |
|---|---|---|---|---|
| Unforced errors | 8.44 ± 2.96 | 8.57 ± 2.80 | -0.36 | 0.05 |
| Forced errors | 4.13 ± 2.15 | 4.14 ± 2.27 | -0.03 | 0.00 |
| Passing error | 0.65 ± 0.83 | 0.58 ± 0.85 | 0.62 | 0.08 |
| Intercepted pass | 0.5 ± 0.69 | 0.39 ± 0.63 | 1.38 | 0.17 |
| Unforced dropped ball | 5 ± 2.17 | 5.06 ± 2.25 | -0.21 | 0.03 |
| Forward pass | 0.31 ± 0.52 | 0.29 ± 0.51 | 0.38 | 0.04 |
| Forced lost ball | 1.76 ± 1.49 | 1.76 ± 1.28 | 0.00 | 0.00 |
| Ball lost in ruck | 1.89 ± 1.52 | 1.95 ± 1.490 | -0.30 | 0.04 |
| Kicked dead | 0.26 ± 0.46 | 0.24 ± 0.50 | 0.41 | 0.04 |
| Missed touch | 0.23 ± 0.48 | 0.18 ± 0.47 | 0.69 | 0.11 |
| Accidental knock on | 0.24 ± 0.48 | 0.29 ± 0.60 | -0.83 | 0.09 |

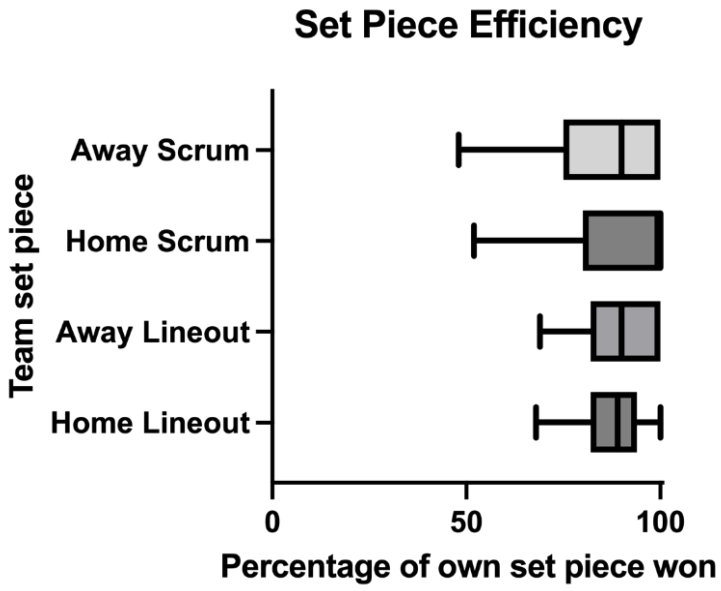


**Figure 5.** Set Piece efficiency under the effects of Home Advantage

## Discussion

The study aimed to explore the acute effects of Home Advantage (HA) in professional Rugby Union during the 2022-2023 Gallagher Premiership season. The analysis revealed that home teams won a significant majority of their games, with a home winning percentage of approximately 69%, aligning with previous research showing Rugby Union having a higher HA than most sports (Jamieson, 2010; Gómez et al., 2011; Pollard et al., 2017).

The most pronounced effect of HA was in try-scoring, home teams scoring significantly more tries than away teams, particularly in the mid and late season. Perhaps indicative of the increased pressure as the season progresses (Wang & Qin, 2023). Contradictory to the assumption that the crowd's presence would be most tangible during quiet moments in the game, placekicking did not have a significant difference. Missed tackles and tackle completions had small effect sizes which suggest that away teams struggle more defensively; Further supported by the small effect size seen on line breaks and defenders beaten favouring the home team. When carrying the ball, home teams gained significantly more ground per carry compared to away teams. The increased on-ball attacking capabilities of the home team and the away teams tackling deficiency can be linked to the increased try scoring for the home team. Away teams were significantly more likely to sustain injuries in the early season. This result could be linked to the stress of travel, a key factor in reducing away team performance (Beckmann, 2022), and poor pre-season preparation. Although no significant differences were found in dominant collision or head injuries, suggesting that the injuries may not be linked to in-game impacts.

Refereeing also played a role in HA, with away teams being penalised more frequently when attacking. Supporting findings of official's bias toward home teams (Edwards & Archambault, 2012). The study also noted that away teams experienced more advantages ending in scrums, suggesting that referees may prolong home team advantages, further contributing to their attacking success. These increased advantages awarding a scrum may also be indicative of poorer attacking play that necessitates returning to the original penalty. Overall, the findings indicate that HA in Rugby Union significantly impacts both offensive and defensive metrics, particularly in the collision area and scoring. These effects are in line with the broader body of HA research, which highlights the role of crowd support, environmental familiarity, and psychological pressures in enhancing home team performance while hindering away teams.

*Implications*

The findings provide valuable insights for teams looking to either capitalise upon or mitigate HA in Rugby Union. For home teams, the results suggest that an aggressive, attacking strategy is beneficial, especially in open play where they experience attacking advantages. Home teams should focus on maximising possession and maintaining attacking pressure to leverage their increased likelihood to beat defenders, break the line and gain ground. Away teams, on the other hand, face clear challenges, particularly in defence. To counteract this, away teams should focus on strengthening defensive cohesion and improving tackle accuracy, as this is an area where they struggle under the effects of HA. Territorial focused play may be an effective strategy. With poor try-scoring and on-ball success, focusing on kicking for territory and scoring through penalties could help reduce the impact of HA. Research on HA in other sports (Pollard, 1986; Gómez et al., 2011) supports this gameplan.

Given that travel has been shown to negatively impact away team performance (Beckmann, 2022), teams should also consider strategies to minimise travel-related fatigue, such as adjusting pre-match routines or ensuring better recovery and nutrition management during away trips. The relational influences of HA and referees on one another further highlights the opportunity to leverage HA. With referees more likely to penalise away teams, discipline is crucial. Home teams should aim to maintain pressure on referees through sustained offensive phases, as the study showed they are less frequently penalised in attacking scenarios.

Finally, injury prevention is a critical consideration for away teams early in the season when they are more prone to injuries. Coaches should prioritise physical conditioning and injury management to ensure players are resilient enough to handle the physical and mental demands of traveling to away venues. In conclusion, the study enables coaches to tailor their strategies to either exploit or counteract the effects of HA. Home teams should emphasise attack and possession, while away teams would benefit from a more territorial and disciplined approach, focusing on minimising errors and travel fatigue. These adjustments could help teams navigate the challenges of playing at home or away, aligning with established theories of HA (Courneya & Carron, 1992) and performance dynamics in competitive sports.

*Limitations*

While this study offers valuable insights into the effects of Home Advantage (HA) in Rugby Union, several limitations must be acknowledged. The analysis focused exclusively on the 2022-2023 English Premiership season, limiting transferability to other leagues and seasons. Unique factors such as team

dynamics or injuries could have influenced results, highlighting the need for research that spans multiple seasons to assess consistency (Jamieson, 2010). Additionally, the study did not account for environmental variables like weather conditions, pitch quality, and travel distances, which can significantly affect performance (Pollard, 1986; Beckmann, 2022). The lack of individual player attributes data such as age, experience, and injury history further constrain the analysis. These factors may influence how players respond to the pressures of HA, as shown in previous studies (Huyghe et al., 2018). Moreover, the research was limited to the English Premiership, which restricts applicability to other Rugby Union contexts where crowd behaviour and venue-specific advantages can vary (Gómez et al., 2011). Finally, while officiating decisions were recognised as a significant component of HA, the study did not explore the specifics of referee biases or crowd influence on officiating.

*Future Research Directions*

There are several promising areas for future research that could deepen our understanding of Home Advantage (HA) in Rugby Union and other sports. One major direction involves expanding the dataset to cover multiple seasons. Since this study focused solely on the 2022-2023 Gallagher Premiership season, further research could determine whether the observed effects of HA are consistent across years, competitions, locations and cultures. Jamieson (2010) highlighted the need for longitudinal studies to track changes in HA over time, and this approach would also help mitigate the impact of anomalies in a single season. Since Rugby Union is played in varying cultural and geographical contexts, examining HA in different leagues or countries could shed light on how cultural factors, affect the magnitude of HA. For instance, research has shown that French rugby teams experience a particularly high HA (Gómez et al., 2011; Pollard, 2017). Location will also have a big impact on the weather conditions and terrain that is played upon.

While this study focused on in-game performance metrics, variables such as travel fatigue and familiarity with playing conditions were noted as potential contributors to HA (Pollard, 1986; Beckmann, 2022). Future studies could incorporate data on these factors to examine their direct effects on player performance. Research that accounts for these variables could help refine our understanding of how travel and environmental conditions exacerbate or reduce HA. The role of individual player characteristics also presents a rich area for future exploration. For instance, older players or those recovering from injuries may experience different effects of HA compared to younger, fitter players. By examining these personal attributes, researchers could gain more insights into which players are most susceptible to the pressures of playing away and how this impacts overall team performance.

Additionally, the psychological aspects of HA warrant deeper investigation. While previous research has linked crowd pressure and territorialism to increased HA (Edwards & Archambault, 2012), future studies could incorporate psychological measures to assess how players' mental states differ when playing at home versus away. Factors such as stress, motivation, and crowd intimidation could be measured through surveys or biological markers like heart rate and cortisol levels. This would allow researchers to explore how mental conditioning and stress management strategies could mitigate the effects of HA for away teams.

From a practical standpoint, future research could also focus on developing targeted interventions for teams and investigating how these interventions affect HA. This approach could also be done for officiating, with attempts to limit referee bias. For instance, understanding how home crowd dynamics impact referee decisions (Wang & Qin, 2023) could allow teams to better exploit the psychological pressures referees face in these settings as influencing their own crowd.

*Conclusion*

This study highlights the significant impact of HA on both offensive and defensive performance metrics in professional Rugby Union. The findings confirm that home teams not only win more games, with a 69% winning percentage, but also outperform away teams in key areas such as try-scoring, ground gained per carry, and tackle completion rates. Away teams, on the other hand, are more susceptible to injuries, especially early in the season, and face a higher rate of penalties when attacking. These results provide critical insights for both coaches and players, suggesting that home teams should focus on maximising their attacking opportunities, while away teams should adopt more conservative, territorial strategies to mitigate the disadvantages posed by HA. Future research should explore these dynamics across multiple seasons and different leagues to determine the consistency of HA effects and examine additional factors such as environmental conditions and player characteristics. Future research should aim to broaden the scope of HA analysis by incorporating longitudinal data, environmental variables, and individual player characteristics. These avenues will help refine our understanding of HA and provide actionable insights for teams and coaches to optimise performance in both home and away games. Such insights would help refine strategies for both home and away teams, enhancing overall performance in competitive rugby.

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## Research Article

# Creating a positive environment in sport and recreation: Insight from qualitative research

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Running Title: Caring climate in sport & exercise

## Abstract

This qualitative study explored how a caring climate influences the experiences of current and future exercise leaders. Through focus groups, we explored how these leaders plan to or are currently creating caring climates within their domains. Interviews were transcribed and analyzed using Dadoose, a thematic coding system, with a structured codebook and hero quotes to highlight key insights. Three major themes emerged: Belonging and Connection; Support, Listening and Accessibility; and Inclusion, Mindfulness and Rapport. Participants emphasized the importance of feeling valued and understood and helped strengthen relationships and foster a more caring environment. They described everyday actions like small talk, collaboration, and one-on-one check-ins as critical attributes for creating a comfortable and psychologically safe environment. Leaders who showed empathy and openness helped athletes feel cared for beyond performance, reinforcing trust and belonging. These findings support existing literature and show how everyday actions and communication contribute to a caring climate. Participants also highlighted strategies such as rotating players for equal participation, encouraging mindfulness, and building rapport through shared experiences. They viewed caring climates as spaces where athletes feel respected, supported, and accepted as whole individuals, not just performers. Overall, this study found that if future sports and exercise leaders use behaviors such as listening, accessibility, and authentic connection, they can build inclusive and supportive environments. By focusing on empathy and intentional communication, leaders can promote confidence, motivation, and a sense of belonging, which are essential for long-term engagement and well-being among all sport participants.

**Keywords:** belonging, emotional safety, focus groups, inclusion, sport psychology.

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# Introduction

*Positive Environment in Sports and Recreations*

In sports and recreation, a positive environment is particularly important because it can help people build motivation, confidence, and feel supported. Incorporating activities like fun team games or team building exercises is a wonderful way to create a positive environment; team building activities play a significant role in helping groups work together more effectively by building trust and improving overall teamwork (Holg, 2024). This can also help create stronger bonds and relationships. According to Lopez & Martin (2024), coaches support athlete development by offering manageable challenges and providing constructive feedback that enhances both skill and confidence level. This shows that when coaches create an environment where athletes feel supported and pushed just enough, they are more likely to put in more effort and stay more engaged in the activity.

*Positive Environment linked to Caring Climate*

A positive environment is characterized by bringing trust, respect, and empathy, often referred to as a caring climate (Fry & Gano-Overway, 2010). A caring climate can help many individuals improve, learn, and increase productivity. A caring climate is one where people feel safe because everyone treats each other with respect, trust, and understanding (Delgado-Galindo et al., 2025). When individuals experience a sense of belonging and receive adequate support, such environments are further enhanced, fostering greater cohesion and effectiveness (Brown, 2019). Overall, these results strongly highlight that a caring climate has a major effect on how individuals and groups operate and perform.

*Defining the Caring Climate*

One key concept emerging from this broader context is that of the caring climate. In sports psychology, a caring climate refers to how much people feel that their environment is safe, supportive, respectful, safe, and focused on their overall personal growth (Newton et al., 2007). According to research by Fry and Gano Overway (2023), when athletes view their environment as caring and supportive, they tend to experience an increase in psychological well-being and social self-esteem. Importantly, a caring climate is not just about winning or being the best, Instead, it’s about everyone, supporting each person's growth, and recognizing the effort they put in. Studying the caring climate helps us connect the social, motivational, and emotional parts of being involved in sports.

*Caring Climate Scale*

Tools like the Caring Climate Scale provide a way to measure participants' perceptions of a caring climate. The survey provides questions about being valued, safe, and welcome by using items that ask participants to rate their agreement on a scale. The Caring Climate Scale is designed to assess how much an environment feels safe, supportive, welcoming, and capable of helping individuals feel valued and respected (Newton et al., 2007). There are many benefits, but they often rely on many recommendations rather than a single model. For example, past scholars suggest concrete strategies for coaches to create this caring climate, such as making participants feel welcome, safe, and respected, and acting kindly (Gano-Overway et al., 2014; Newton et al., 2007). Overall, the caring climate scale helps us understand how athletes feel in many environments but does not tell coaches exactly how to create that exact climate.

*Connection and Relationships*

In Brown and Fry's research study, they found that the fitness members of the club perceived certain items such as behaviours of helping, caring, and interaction (Brown & Fry 2014). These perceived behaviours were measured by using Brown and Fry's 15-item Staff's behaviour scale and 7-item Member's behaviour scale. With that, it has been observed and recorded that having a platonic caring relationship with the client increased the total exercise commitment score (Brown & Fry 2014). This is reflected in the Theory-Driven Meditation Model as it suggests that the perception of staff behaviours would indirectly predict members' experiences through their perceptions of the climate (Brown & Fry 2014).

*Accessibility, Inclusion, and Belonging*

With increased statistics of participants having some type of disability, cognitive or physical, accessibility, inclusion, and belonging play a big part in one's participation. The basic definition of inclusion in our context is, "Inclusive education has been defined broadly and varied referring to a variety of aspects of inclusion such as access, rights, participation, belonging, and employment, which can create difficulties operationalizing inclusion" (Long 2024). The physical therapist views the elements of a caring climate as more related to education than therapy. However, these elements are still important because coaches teach athletes in a comparable way that teachers instruct students. Long also states that support is important to one's participation and belonging. He suggests, "Service providers need appropriate support and resources, such as training and on-going opportunities to collaborate with other professionals, to design and implement the kinds of intervention programs that foster participation leading to belonging" (Long 2024). Again, while this includes more of a medical

background, this is vital to understand due to the physical therapist's role in patient care—being a leader and health coach in efforts for them to improve their physical state. With all of this in mind, caring climate does not just apply to physical activity instructors, but to other professions that emphasize accessibility, inclusion, and belonging as well.

*Mindfulness and Authenticity*

With the United States shifting to a more fast-paced economy and society, value in mindfulness and authenticity have increased when one considers participating in a healthy lifestyle. Ms. Cockrell states in her research that, "...The practice of mindfulness can help reduce the anxieties, struggles, and mental flaws which cloud our perception" (Cockrell et al., 2011). Ms. Cockrell highlighted the potential influence of mindfulness on individuals' engagement in activities, particularly through their relationship with perceived confidence and self-efficacy. In a caring climate, a coach or physical activity instructor would encourage others to improve their mindfulness while maintaining authenticity towards the client.

In relation to our research project, it is important to acknowledge gaps in the existing literature, including the lack of research designs that adequately account for initial differences, the absence of control groups to address demographic variations prior to study initiation, and the need for rigorous investigations involving actual children and authentic exercise programs (Newton et al., 2007). In a general sense, this is understandable to have a control group that has not been impacted in any way, shape, or form is difficult to obtain. Accordingly, the purpose of this qualitative research was to explore how participants plan to develop a caring climate for others in their careers as sport health and exercise professionals. The authors hope to bring more discussion and research with the results produced by this study towards caring climate in sport and exercise environments.

## Methods

*Participants and Recruitment*

All activities were approved by the lead author's Institutional Review Board at the time of the study (IRB-FY2026-69). Sixteen participants took part in this study (nine men, seven women, eight current university students, eight non-students). Participants were predominantly White and non-Hispanic, with an average age of approximately 24 years. Individuals included those currently working in sports, health, and exercise fields, those aspiring to work in these fields, and those who had previously worked in these fields (e.g., physical therapists, physical education teachers, strength and conditioning coaches, student athletes). Research team members sent out e-mails to recruit participants.

Recruitment flyers were shared in the instructor's classes, and social media posts by Kinesiology department. Convenience sampling was employed to collect perspectives from individuals with diverse positions and experiences (Golzar, et al., 2022).

Participants were entered into a drawing to win one of twenty-five gift cards as an incentive for participation in this research. Snacks were also provided to make participants feel welcomed and invited. These incentives were funded by the research team's home institution. All participants agreed to participate in this study and were informed they could withdraw from the study at any time without disadvantage. Participants were also provided with contact information from the research team if they had any follow-up questions.

*Focus Group Design and Rationale for Focus Group*

This study employed three semi-structured groups as a qualitative data collection method. The first group comprised eight participants, the second group comprised five, and the third group comprised three. Group assignments were based on participant schedules, with participants having backgrounds related to sports, exercise, and health mixed together. Reasons why the groups were divided into three were to facilitate smooth discussion and ensure each person had sufficient time to speak. Each session lasted approximately 20 to 40 minutes and was conducted at research team's home institution. To enhance visibility among participants and encourage open discussion, seating was arranged in a circle. Prior to conducting these sessions, the research team completed pilot interviews in class to practice focus group facilitation, which helped strengthen methodological rigor given the novice status of the team within the research domain (Malmqvist et al., 2019).

Focus groups were adopted as a primary data collection method because participants complement each other's opinions, enabling the discovery of commonalities and differences that are difficult to uncover through individual interviews. Previous research indicates this method is effective for exploring themes such as caregiving experiences, organizational support, and psychological safety (Bates & McShan, 2025).

*Procedure*

This study facilitated discussions using a semi-structured focus group guide containing eight open-ended questions. The analysis employed deductive qualitative analysis grounded in the caring climate framework (Newton et al., 2007). The guide included introduction, questions, discussion, and closing. The facilitator asked probing questions as needed to assist participants in elaborating on their experiences and feelings. Assistant facilitator assisted facilitator to have smooth discussion. Note-

takers observed participants' non-verbal expression during interviews for getting additional analysing resources. Audio recorder recorded all sessions and made minutes using Microsoft Word automatic transcription feature (Microsoft Corporation et al., 2024). The same questions were used across all three groups to ensure consistency and reliability. Questions were asked by same order in all the sessions. The list of questions is presented as Appendix A.

*Data Collection and Analysis*

The roles outlined in the procedure remained unchanged to minimize potential bias. All focus group sessions were audio-recorded with participant consent. Note-takers documented participants' gestures and facial expressions to supplement the recorded data. The data was stored on a university-encrypted cloud service. Only the research team could access the cloud. Following this framework, participants' statements were systematically coded and organized into themes and subthemes (Dedoose, 2023). Dedoose was used to visualize and explore thirty pages of transcribed data and audio recordings.

*Reflexivity and Trustworthiness*

The research team consists of seven members, comprising four men and three women who are majoring in Kinesiology in a master's level program. The mentor of the research team edited the manuscript and helped the rest of the research team learn about the process of qualitative research. This composition minimizes the influence of gender-based biases, and since the research team's background and participants' background is similar, it would be easier to understand participants' opinion. Consistency was ensured by asking the same questions in all sessions. Separating facilitation and observation roles also enhanced process transparency. The interviewer maintained a neutral stance throughout, minimizing influence on participants to ensure reflexivity. Additionally, the group's mentor contributed by editing the manuscript and guiding the team through the qualitative research process, providing essential support for developing methodological rigor.

## Results

Participants described several helpful behaviours underlying a positive sport and exercise environment as they reflected on how they plan to or currently do create a caring climate. Overarchingly, the participants described important aspects of this environment to include the importance of being seen, feeling safe and supported, and having a level of connectedness to create a caring climate. Notably, all these themes were consistently discussed throughout interviews and focused on how they help the participants create the desired environment. Themes included:

belonging and connection with the subthemes: comfort, understanding, supportive guidance and a psychologically safe environment; support, listening, and accessibility; and inclusion, mindfulness, and rapport.

*Belonging and Connection*

Participant responses described the theme of belonging and connection as they discussed how they strive to create a caring sport and exercise environment. Creating the sense of belonging and connection deepens the relationship with the athlete or client. This also revealed the subthemes of comfort, understanding, supportive guidance, and psychologically safe environment. One participant recalls the quality of this theme by saying the following, "My high school coaches were particularly good with one-on-one check ins. How are you doing? Do you want to succeed?... What are you struggling in?" The previous quote is an example of how asking the athlete about how things are going in both the sport and exercise environment and their personal life increases the connectedness for the individual. Participants described connection as developing through consistent communication, collaboration, and shared experiences that strengthen relationships. Ten of our participants stated the importance of everyday interactions in building relationships, like "Talking to your coworkers at lunch" and "Building connections outside of it [sport and exercise environment] like increase the small talk." Others mentioned collaboration as an avenue connect with each other. To further this point, one participant stated, "Communicating with different organizations and facilities and try to collaborate together, making connections." All together, these responses showed that genuine connection and belonging is formed when individuals take time to engage with one another beyond formal roles or structured activities.

*Comfort*

The subtheme of comfort emerged from discussion as another avenue to foster belonging and connection. Participants strived to emphasize the importance of creating an environment where they feel a state of physical ease and freedom from constraint. One participant described the ideal approach to creating a comfortable environment as follows:

See where they are at [clients, athlete, staff, etc.] and where they are comfortable being at, so that we can build from there… talking to them and getting to know them during their sessions. So, it is not just like I [the coach] am telling you to do something… building a connection with them."

Creating comfort in the environment goes a long way to open more routes for communication, leading to a more meaningful and beneficial relationship for the parties involved. Another participant, who is pursuing a career in physical therapy, shared the following about creating a caring climate, "I want my patient to feel comfortable in that setting. So, letting them know that they can tell me when something is too difficult." This is one example of when a sports and exercise leader can effectively foster comfort in their practice through communication. These quotes all show that feeling at ease and opening the pathway of communication with the sport and exercise leader makes clients and athletes feel comforted.

Twelve of our sixteen participants also highlighted that their level of comfort were heightened when the coach showed they cared for them even when they are not the star player, and if the coach cared for them as a person, not just an athlete. "…Making sure that they feel cared for, even if they're not having their best day." This participant highlights that it is important to show you care for them as a person, regardless of their performance in the environment, to make them feel comfortable, and in turn, increase their sense of belonging. Overall, the impact that caring for the person is an important attribute for a sport and exercise leader to adopt in creating a comfortable environment.

*Understanding*

Participants described helpful behaviours in fostering a caring climate involves showing understanding. This subtheme highlights that demonstrating empathy and emotional awareness was a key part of how participants showed care. Put simply, one of our participants summarizes understanding as, "The art of noticing, even when I'm off the slightest." The consensus from participants of this subtheme of understanding seems to be centred around the idea that knowing someone, to understand them. One participant said "showing that you care about them outside of being an athlete" was necessary for creating a caring climate. Several participants agreed with the statement either verbally or with a head nod. "Be receptive of how you react to certain things… they need encouragement, or if they need acts of services." This quote highlights the need for the sports and exercise leader to understand the personality of a person to treat them in a way they are receptive to, to enhance their experience. This subtheme shows that a sports and exercise leader needs to know someone on a more personal level so they can understand if someone is having a difficult day or understand how to best communicate with someone to make them feel cared for in their situation.

*Supportive guidance*

Participants described the importance of offering encouragement, advice, and responsive feedback to meet individual needs. They describe this supportive guidance as "positive reinforcement" and "always there to support… regardless of how the sport went." One detail discussed was "being noticed at practice and giving critiques and saying when you do good, when you do bad." This has to do with noticing the individual as someone with potential, giving them both support and guidance to help them improve. This was highlighted as an important behaviour for sports and exercise leaders to possess. A participant suggests a practical application for a leader to use would look like, "Give me feedback on how you are feeling at all points throughout the session if there is anything you want to change, and giving them opportunities to make change or choices." This encompasses the whole behaviour of seeing a person, guiding the person, and having that desire to make them better in an encouraging and uplifting way. Overall, understanding a person deepens the relationship and this quality is necessary for creating a caring climate.

*Psychologically safe environment*

Several of our participants highlighted the importance of feeling safe. In a psychologically safe environment, individuals feel comfortable expressing themselves without fear of negative consequences such as embarrassment, rejection, or punishment. Some ways discussed to avoid these fears of negative consequences were, from one participant. "Letting them [the athlete] know that they can tell me when something is too difficult." Another participant shared this: "letting everybody know that I am here for them, whether it is in the sport or exercise." The consensus when asked how they will plan to accept people as sport and exercise leaders was "creating a safe, comfortable environment." This opens communication and develops the relationship that several refer to as feeling cared for. Overall, discussion from the participants reflects on the lengths that leaders can reach to show others that they care for them and make them feel psychologically safe. This allows sports and exercise leaders to deepen their relationship with athletes and/or clients, and in turn be more successful in making them feel like they belong and connected within the group.

*Support, Listening, and Accessibility*

The theme of support emerged from discussion among participants. It was spoken of in accordance with care and safety, as another measure that plays a large factor in creating a caring climate as a sport and exercise leader. When discussing the need to be a supportive sport and exercise leader, several of our participants described achieving this as listening and being accessible to athletes, clients, or coworkers. One participant tells us that support involves, "Just being there no matter what is [going

on]. Just trying to support them as best I can." Simply put, being there and being someone for the people to turn to for anything is how the participants viewed support and its role in creating the ideal caring environment. Participants described being accessible as, "an open-door policy with the coach" and listening is, "creating a connection with them, whether that be talking to them or doing exercises with them." These are just a couple of examples of what participants discussed as ways they have seen successful listening and accessibility of a leader that enhanced their caring climate. Overall, the participants felt that it is important for leaders to "express that you're open to people coming to you and being able to talk to you." The quote shows that giving people this accessibility to you as a leader to open time for communication and talking about things outside of the realm of sport and exercise. "Being attentive and listening to what they have to say," was a quote that is the overarching consensus of breaking down barriers and opening a relationship with athletes, clients, and coworkers in sport and exercise. This helps sports and exercise leaders be able to support those they work with, through being accessible and listening.

*Inclusion, Mindfulness, and Rapport*

Participants frequently described the importance of inclusion, mindfulness, and rapport as part of a caring sport and exercise environment. Inclusion was collectively discussed as fair treatment, shared opportunities, and ensuring that all participants felt they were valued, no matter their skill level. Many of our participants mentioned that "giving everybody fair treatment" and "no special treatment, being inclusive" were necessary behaviours for coaches and leaders. Several of our participants also emphasized the importance of rotating or substituting people to ensure equal participation, explaining that "cycling people in and out instead of just keeping the starters in" allows for everyone to have an opportunity to gain experience and contribute to the team. Participants described how team bonding, group activities, and open communication helped people feel more comfortable and connected to others. Some participants suggested "Activities and competitions that would bring that group together to help build more of a family, so you're talking to people that you wouldn't usually talk to", "Ice breakers, team bonding, things like that can really get people out of their comfort zone" and "Coaches taking the time and effort to teach someone like me that has zero experience with the sport." Participants also mentioned collaborating with teammates outside of sports, like "Ask people to form study groups, and that's a good way to not only work on your schoolwork but also get to know through that." Overall, participants emphasized that inclusion was noticed when leaders and peers created inclusive spaces where everyone felt recognized, supported, and part of a group. This sense of inclusion contributed to stronger connections and a more caring environment within sport and exercise.

Participants talked about mindfulness as an important part of a caring environment. Mindfulness is the quality or state of being conscious or aware of something or someone. They described mindfulness as the ability to remain open, understanding, and present with others in sport and exercise settings. Many of them discussed that being mindful involves treating other people with acceptance and empathy, while staying fair and aware of their own biases. One participant said, "don't judge, listen to people and you should be accepting," and another noted the importance of "being open and honest and direct about the task at hand whether it's taking care of the patient or teaching someone to support." Participants emphasized that when coaches of other leaders demonstrate openness and emotional awareness, it helps others feel comfortable, supported, and more connected. Mindfulness was shown in participants' emphasis on being genuine, transparent, and nonjudgmental. This can be described as embracing others as they are while being emotionally available to yourself. Multiple participants said, "don't judge, listen to people and you should be accepting" and "Giving that reassurance that who you are as a person is going to be accepted." Some described the importance of removing bias, "Eliminate your own personal opinions about your athletes." Mindfulness was seen through openness and honesty, like one participant who said, Furthermore, participants stated that being transparent and direct about tasks, "Being open and honest and direct about the task at hand..." helps to generate genuine communication, making athletes and clients feel more included and connected to the leader. Overall, responses suggested that authenticity is a key component in creating mindful and caring sports and exercise environments.

Rapport was seen from participants focusing on mutual understanding, shared experiences, and meaningful dialogue. Participants described rapport as finding common ground and showing openness to others' perspectives, which helped build trust and comfort. One participant stated, "Try to find common ground, be open to what they say and remember them and make them feel really special." Participants also said that maintaining small talk and showing a genuine interest in others supported building strong relationships and an improved collaboration with others. One person said, "Having small talks with them, getting to know them, who they really are and building that relationship and keep growing." Overall, rapport is an outcome that derives from communication and mutual respect, which allows people to feel valued and connected within their sport and exercise environments. Altogether, inclusion, mindfulness, and rapport build from one another and increase the quality of the relationship between a sports and exercise leader and the people they work with. All these attributes are deemed helpful to the sport and exercise leader as they seek to create a caring climate for athletes, participants, and clients in their careers.

## Discussion

The aims of this research were to investigate characteristics of sport and exercise leaders in current and future positions to identify as essential for creating a caring environment. During our interviews, participants highlighted several notable observations. Themes from this research are Belonging and Connection; Support, Listening and Accessibility; and Inclusion, Mindfulness and Rapport. The subthemes that are associated with the themes are comfort, understanding, supportive guidance, and a psychologically safe environment. A major contribution to the literature that this research study provides is its focus on the intentions of future leaders rather than solely examining the experiences of past athletes. The study shifts its emphasis from reflection to intention which contributes to the development of the field. The new leaders have started to consider methods for implementing empathy and inclusive communication practices in their professional work. The execution of these strategies may result in higher client and athlete appreciation, which may enhance their dedication to exercise and sports activities.

Previous research emphasizes the importance of fostering caring climates for enhancing motivation, inclusion, and personal growth. However, there has been comparatively less attention on the specific strategies leaders employ to create such environments. This study addresses that gap by examining the actions and behaviours sport leaders currently use or intend to use to cultivate a caring climate. One notable approach involved leaders engaging in conversations with players and clients about non-sport-related topics while actively listening, which generated feelings of being seen and supported among participants. This finding aligns with prior research on college athletes, where genuine communication from coaches contributed to athletes feeling cared for on a personal level (Schools et al. 2020). Similarly, Gano-Overway et al. (2023) reported that situational and personal factors can either enable or impede their efforts to foster caring climates, such as time, resources, culture, and individual leader dispositions. The participants in this study mentioned that being accepted by others gave them a sense of belonging to the group. This connects closely to Long's (2024) idea that inclusion and belonging are essential if people are going to do more than just "get by"; they need to be able to thrive and flourish in their environments. Leaders in caring sport environments need to maintain ongoing interest in athletes' personal lives which reach beyond their athletic achievements, according to the research.

The leader in exercise and sport is clearly essential to overall experience. Leaders who established protected areas and open dialogue channels enabled participants to experience support and motivation and stronger group connections. This aligns with the 3 + 1 C model (Jowett et al., 2016),

which emphasizes closeness, commitment, and mutual understanding between coaches and athletes as foundational for positive relationships. Furthermore, this model complements the COMPASS model (Rhind et al., 2010), which highlights openness and support as essential components for maintaining strong interpersonal bonds. These theoretical models reinforce the behaviors observed in our study, demonstrating that intentional communication and relationship-building strategies are central to fostering caring climates. Interestingly, Xu et al. (2025) found that personality traits, such as extraversion, can affect how athletes see a caring and supportive climate. Together, these findings illustrate why leader behaviors and athlete dispositions must be considered jointly when creating environments that promote belonging and psychological safety.

*Implications*

The research findings deliver critical information, which may be valuable to leaders in the sports and exercise fields. One implication is that when training future leaders such as trainers, therapists, and exercise instructors, that training should consider including teachings related to the importance of creating a caring climate. Past research has highlighted that environments which provide care and inclusiveness create better athlete well-being and stronger commitment (Hogue et al. 2017; Gano-Overway et al. 2023). The study demonstrates that small gestures between coaches and athletes which appear unimportant, build trust and create feelings of belonging. Self-Determination Theory (Deci & Ryan, 2000) provides a useful lens for understanding our findings, as it emphasizes that motivation increases when individuals' needs for relatedness, autonomy, and competence are met. Leaders who establish relationships through care create stronger connections that enhance the enjoyment and significance of sports activities. Similarly, Bandura's (1997) concept of self-efficacy is relevant because participants described feeling more confident when leaders offered encouragement and reassurance. Caring leaders can provide naturally through encouragement and reassurance. Education and professional programs should expand their teaching to include direct instruction of relational skills. The COMPASS model (Rhind et al. 2010) serves as a method to achieve this goal through its framework which supports transparent communication and motivational support and confidence-building measures. Paired with the 3 + 1 C model (Jowett et al., 2016), which emphasizes closeness, commitment, and mutual understanding, COMPASS demonstrates the value of companion models that address both relationship quality and practical behaviors. The training programs for coaches at schools and community organizations should implement the same framework to educate future leaders about building compassionate relationships and handling challenges effectively.

*Limitations*

The following section will highlight some of the limitations of the study. The largest of these was sample size. Despite the intention of having five or six people per group, turnout was lowered by inclement weather and scheduling conflicts. The study was limited by the small number of participants, which made it difficult to examine different experiences. The participants brought diverse sport experiences to the study since some competed at an elevated level while others played for recreational purposes which could have influenced their understanding of care. Additionally, this was a pilot study conducted by novice researchers, which introduced constraints related to methodological rigor and experience in qualitative research processes. Future studies need to conduct this research with a larger diverse participant sample while observing leaders over time to monitor their intentions until they transform into actual organizational actions. The evaluation should concentrate on actions which create feelings of care through communication techniques and feedback strategies.

*Conclusion*

This research adds new knowledge about a caring climate through its examination of sport and exercise leaders' approaches to climate development. The participants experienced care through communication which functioned as the unifying element between them because they maintained open dialogue and active listening and continuous support. Importantly, caring climates are not only essential for athletes but also for individuals engaged in exercise and health-related activities, as these environments promote sustained participation and overall well-being. Leaders who focus on empathy and openness and inclusion will establish spaces where athletes experience value as complete individuals beyond their athletic performance, which becomes essential for their continued engagement and motivation and success. Such environments ensure that exercisers, fitness participants, and other non-athlete groups also feel supported and valued, reinforcing the broader applicability of caring climate principles across sport and exercise contexts.

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## Research Article

# "A team wouldn't be without a physio, so why miss mental health?": Exploring the psychological demands of increased exposure and available support for female footballers

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## Abstract

The increased profile of women's football has been evidenced by greater fan presence and media exposure in England, which presents unique challenges for players, alongside an opportunity to explore the impact on players and psychological support provisions available. A total of 133 female footballers competing across the top four tiers in England volunteered to complete an online survey hosted on Jisc. The survey comprised of 42 questions, including open-ended and Likert-scale questions, developed around four themes: 1) general perspectives regarding increased attention; 2) performance; 3) psychological implications of increased crowd presence, and 4) player support and coping mechanisms. Open-ended responses were thematically analysed in line with Braun and Clarke's (2006) six-step approach. Players referred to inspiring others, career fulfilment, professionalisation, and mental health benefits (e.g. pride) as positives associated with the game's progression. They also described negative consequences, including increased pressure and anxiety, heightened scrutiny and abuse, balancing multiple demands with limited resources, and inadequate infrastructure to support the rate of growth. Overall, 64.7% of participants stated they would like more psychological support from their club. Key stakeholders should therefore seek practicable solutions to enhance the often-neglected psychological support available.

**Keywords:** coping, crowd presence, stress, support, soccer.

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## Introduction

There has been a heightened appetite for watching women's football in recent years (Allison & Pope, 2021), following the re-administration of the women's football league by the Football Association (FA) in 1971, after it had been banned 50 years earlier, with the FA deeming that "…the game of football is quite unsuitable for females and ought not to be encouraged" (Department for Culture, Media & Sport, 2023). It was not until 2018 that the UK saw the topflight of women's football become professional, reflecting the relatively emergent stage at which the women's game remains (Department for Culture, Media & Sport, 2023). At the time of data collection, the Women's Super League (WSL) (Tier 1) consisted of 12 fully professional teams, while the Women's Championship (WC) (Tier 2) comprised a mix of professional and semi-professional teams. The Women's National League (FA WNL) (Tier 3 and Tier 4) formed the third and fourth tiers of the women's football pyramid and comprised of six divisions. The Northern and Southern Premier Divisions acted as Tier 3, with the Division One North, Midlands, South-East and South-West leagues residing in Tier 4. There are significant differences in the provisions and financial resources available to clubs within and between leagues in the women's football pyramid (Department for Culture, Media & Sport, 2023), demonstrated by some players competing within Tiers 3 and 4 remaining unpaid and of amateur status, while others are on full-time contracts. Since data collection, the league structure has evolved, with the top two tiers transitioning toward full professionalism (WSL Football, 2025); however, original terminology is retained here to reflect the competitive structure during the study period.

During the 2022-23 season, both the WSL and WC saw record attendance figures. Notably, the Women's FA Cup Final attracted a turnout of 77,000 (Department for Culture, Media & Sport, 2023), and the Emirates Stadium hosted over 60,160 fans, setting a new WSL attendance record (BBC, 2024). Increased fan presence has also been evidenced within Tiers 3 and Tier 4, with attendances of over 28,000 recorded for Tier 4 matches during the 2022-23, with average attendances ranging from 40 up to 3,817 at the same level. This growth presents a unique set of challenges for players unaccustomed to heightened exposure, alongside a novel opportunity to explore the impact of increased interest and attention on female football players.

The increased profile of women's football has resulted in a growing number of international competitions, as well as professional and recreational leagues across age groups for female players. This expansion has provided more opportunities to compete in professional and/or semi-professional environments, in turn increasing performance expectations and associated physiological and psychological demands (Wheatley et al., 2023). Whilst research attention toward the women's game

has increased in response to these demands and heightened exposure (e.g. prevalence of anterior cruciate ligament injury), a recent government review, 'Raising the bar – reframing the opportunity in women's football' (Department for Culture, Media & Sport, 2023), highlighted a substantial gap in research evidence focused on supporting female athletes both physically and psychologically (Cowley et al., 2021). Just 6% of sport and exercise science research focuses solely on women (Cowley et al., 2021) and to date, most investigations have focused on player characteristics and physiological demands (Martínez-Lagunas et al., 2014; Randell et al., 2021), negating important psychological considerations contributing substantially to player performance and wellbeing.

*Impact of Increased Attention on Performance*

Increased attention drawn toward the women's game in recent years has been evidenced by the higher crowd presence, increased media coverage (both in mainstream and social media), and heightened investment and commercialisation. Whilst there are many perceived benefits to this growth, it may also present challenges for players. When individuals are put under the spotlight, where skilled acts are socially evaluated (i.e., athletes) they may experience apprehension, even when drawing positive attention from others (Beilock & Gray, 2007; Chow & Mercado III, 2020). For some athletes, performance anxiety can lead to significant distress, negative effects on emotional state, and impair performance. For others however, apprehensive feelings may positively boost performance (Ruiz, Raglin & Hanin, 2017).

For some female footballers, performing in front of larger crowds (particularly when infrequent) or under a bigger spotlight (i.e. media coverage), self-efficacy may be low due to less experience in such conditions (Bandura, 1997). This may increase uncertainty regarding their ability to cope, negatively affecting perception of control and, in turn, on-field performance. The psychological and performance responses to the heightened attention are individualised. Factors such as individual personality traits (e.g. perfectionist), past experiences, as well as support available (Meijen et al., 2020), may all influence whether a player thrives or struggles under the additional pressure of increased exposure and heightened expectations.

Further, previous research has highlighted that athletes are likely to receive abuse on social media (Meggs & Ahmed, 2021), with reported increases in online abuse and dehumanisation following performance errors or regarding their personal life (Duggan & Brenner, 2012; Lenhart et al., 2010). This is especially prevalent for female athletes (Kavanagh et al., 2019; McCarthy, 2022), who may face additional gender-based discrimination compared to their male counterparts. Research by Fenton and

colleagues (2023), exploring the escalation of online gender-based violence in women's football by observing the social media accounts of two high profile teams in England, identified four key themes: 1. Sexism regarding women's place in football; 2. Misogyny and hatred of women; 3. Sexualisation of women; and 4. Demands for a male-only space. The authors also concluded that other dominant online comments frequently sought to objectify women for sexual desire, belittle professional competence, and showed outrage toward representation of female players on official club platforms. The increasingly prevalent additional gender-based discrimination and abuse described, in conjunction with the increased media profiles of many women's teams within the UK could have detrimental effects for players wellbeing.

Whilst there are many perceived benefits to the growth and increased attention drawn toward women's football, it is important to understand the contemporary demands of the game and to hear directly from players regarding their experiences of competing in the top four tiers in England. Importantly, increased attention and professionalisation should not be assumed to be exclusively positive for all female players. To date, however, there has been limited research exploring players' perceptions of how this growth has impacted both performance and psychological wellbeing.

Psychological Support in Football

Sport psychology is being increasingly recognised and accepted within elite football, despite historically being less prioritised than physical, technical, and tactical support (Dean et al., 2022). The role of a sport psychologist is diverse in nature, involving working with athletes, coaches, teams, and significant others to help facilitate performance and support factors such as injury, stress, emotional control, leadership, motivation, confidence, and career transition (Gilmore et al., 2018). Despite this, some resistance toward incorporating sport psychology services remains, but athletes' psychological skills are now understood to be crucial for sporting success and career progression in football (Gledhill et al., 2017; Sarmento et al., 2018), though to date, research has focused predominantly on male footballers.

In 2012, the English Premier League mandated the inclusion of psychology within the Elite Player Performance Plan, incorporating psychological testing, lifestyle management, mental skills education, and psychological support from accredited (British Psychological Society or British Association of Sport and Exercise Sciences) sports psychologist within male player development programmes (Dean et al., 2022). However, when hearing from practitioners responsible for delivering sport psychology within elite football academies in England, Dean et al. (2022) summarised that players reported ongoing

ambiguity regarding the psychologist's role, alongside a persistent stigma framing sports psychology as a service designed primarily to "solve problems", rather than to support performance and player development more holistically through education in development and execution of useful psychological skills to optimise players' psychological state.

Whilst progress has been shown with the inclusion of sports psychology within the men's game, no equivalent regulatory framework exists within women's football. Female footballers can currently only access wellbeing support through the Professional Footballers' Association if they are current or former WSL players, leaving many professional or semi-professional female athletes within the WC and FA WNL without access to any such support services. This is particularly concerning given evidence suggesting that female football players may be at higher risk of mental ill-health than their male counterparts (Perry et al., 2022). Perry et al. (2022) highlighted a worryingly low percentage of elite female football players (Tiers 1 and 2 in England), with just 28% of those surveyed, receiving psychological support from their club, despite 86% indicating a need and desire for psychological support. These findings highlight the importance of exploring both semi-professional and professional player perspectives further, particularly with the continued growth of the women's game. Therefore, there is a need to comprehensively understand the psychological demands faced and existing supporting provisions in place for female players, particularly across the top four tiers of the game, where individuals have been exposed to increasing demands over recent years. Athletes should be provided with necessary psychological support to ensure they are equipped with knowledge and skills to effectively cope and thrive in performance environments.

*Rationale and Research Aims*

The popularity of female football is growing rapidly, leading to heightened demands on players competing at high standards. Whilst a growing body of research has begun to focus on the elite side of the women's game, it remains sparse in comparison to the quantity of research in men's football. Most research in the field of women's football has focused on sports medicine, physiology, and sociology, with less focus given to psychological factors (Kryger et al., 2022). Indeed, a recent scoping review highlighted a need for a greater understanding of psychological phenomena within women's football (Gredin et al., 2023). Whilst elite level football has also dominated the existing research to date (Gredin et al., 2023; McGreary et al., 2021; Perry et al., 2022), it is equally as important to explore the perspectives of semi-professional female footballers residing within the WC and within the FA WNL. These players may experience different and/or additional stressors, (e.g. working multiple jobs and having reduced access to club resources). Moreover, the noticeable growth in popularity is

increasingly filtering through to these levels in recent times, placing greater demands and expectations place on players.

To date, it is understood that there has been no research exploring players' perspectives on the recent rise of women's football in England in relation to performance, psychology (and wellbeing), across FA WNL level and above. Therefore, the aims of this study were threefold:

1. Explore female footballers' perceptions of the benefits and challenges associated with heightened exposure and increased crowd presence.

2. Examine the perceived performance-related and psychological (including wellbeing) implications of this increased exposure among players competing across Tiers 1-4.

3. Investigate players' access to psychological support and their views on what support is needed to help them cope with, and thrive under, the modern-day demands of the women's game.

## Methods

*Research Paradigm*

This study is grounded in the pragmatic paradigm, which values flexibility in philosophical perspectives and conceptions of reality (Creswell & Creswell, 2018). Pragmatism holds that reality is continuously shaped by human actions and experiences, prioritising practical problem-solving over a rigid division between mind and external reality (Weaver, 2018). This paradigm supports integrating pluralistic approaches to gain a more comprehensive understanding of the study's aims and research questions (Creswell & Plano Clark, 2018; Shannon-Baker, 2016). Methodologically, pragmatism favours a mixed-methods design, blending quantitative and qualitative approaches to deepen insights into complex phenomena, thereby offering readers more assurance in the research findings and conclusions (Creswell & Plano Clark, 2007, as cited in Creswell, 2011). In line with this pragmatic approach, researcher positionality was actively considered, and reflexivity was practised throughout the study, informing decisions and interpretations across both quantitative and qualitative components, including the research design, data collection, data analysis, and presentation of findings.

*Research Design*

This study adopted a concurrent mixed-methods design, enabling the simultaneous collection and analysis of qualitative and quantitative data. This approach provides a more comprehensive understanding of participants' experiences (Creswell & Creswell, 2018). By employing an online survey for concurrent data collection, participants were able to quickly and conveniently share their experiences, requiring only a single engagement period. This process not only facilitated participation but also allowed the research team to reach a large sample size. From a reflexive perspective, the research team critically examined how their disciplinary backgrounds and experiences within football might influence research design decisions. The team comprised researchers with academic training in sport psychology and sport sciences, alongside varied experiential engagement across football contexts. The lead supervisor has prior playing experience within the FA WNL (Tiers 3 and 4) and is currently involved in coaching women's and girls' teams. This experiential knowledge informed the development of survey items and enhanced contextual sensitivity throughout the study. In contrast, the lead researcher has experience within men's football but no direct involvement in women's football. This positionality was regarded as a strength, as it helped mitigate assumptions rooted in lived experience of the women's game. These complementary perspectives informed the selection of a concurrent mixed-methods design, enabling quantitative breadth to be balanced with qualitative depth and ensuring participants' voices were foregrounded alongside statistical patterns. Additionally, integrating qualitative and quantitative data enriched statistical findings with detailed lived experiences, resulting in a nuanced understanding of how increased exposure in UK women's football affects female players' performance, wellbeing, and need for psychological support.

*Sampling and participants*

The criteria that informed the purposive sample comprised individuals who competed in the WSL, WC, or the FA WNL during the 2022-23 season; were able to access the online survey; and were willing to answer openly about features of their profession. Following ethical approval (FHS 22-23.85) from the first author's institutional Research Ethics Committee, participant recruitment commenced using direct and indirect networks. Firstly, a direct approach was adopted, whereby the first author liaised with contacts within their existing football network (e.g. club managers, team captains, and players). This was followed by an indirect recruitment approach, with all members of the research team sharing the survey link and recruitment information on various social media platforms (i.e. Instagram, Twitter, Facebook and LinkedIn). Snowballing sampling was adopted as a secondary recruitment strategy, whereby players were encouraged to share the survey within their local networks (i.e. with other players) who could potentially offer valuable insights. A target sample of 150 participants was set to

account for ~10% of the participant pool. Data collection was concluded when the research team determined that sufficient data had been gathered to address the research aims, alongside the pragmatics of conducting the research within a realistic timeline (Braun & Clarke, 2021). Participants provided electronic informed consent upon reviewing the participant information sheet. Respondents under 18 years of age were required to gain consent from a parent or guardian. All respondents were randomly assigned a unique participant code by Jisc Online Surveys upon completion to ensure anonymity and confidentiality. The final sample comprised of 133 participants (See Table 1 for participant characteristics).

**Table 1.** Participant characteristics.

| Characteristic | Total (n = 133) | % of sample |
|---|---|---|
| **Age** | | |
| 16 – 17 years | 2 | 1.5% |
| 18 – 21 years | 48 | 36.1% |
| 22 – 25 years | 37 | 27.8% |
| 26 – 29 years | 28 | 21.1% |
| 30 – 33 years | 16 | 12.0% |
| Over 34 years | 4 | 3% |
| **Football League (22-23)** | | |
| FA Women's Super League | 6 | 4.5% |
| FA Women's Championship | 8 | 6.0% |
| FA WNL Northern Premier | 28 | 21.1% |
| FA WNL Southern Premier | 10 | 7.5% |
| FA WNL Div One North | 20 | 15% |
| FA WNL Div One Midlands | 27 | 20.3% |
| FA WNL Div One South East | 16 | 12.0% |
| FA WNL Div One South West | 18 | 13.5% |
| **Position** | | |
| Goalkeeper | 12 | 9.0% |
| Defender | 49 | 36.8% |
| Midfielder | 40 | 30.1% |
| Forward | 31 | 23.3% |
| Other | 1 | 0.8% |
| **Years at WNL or above** | | |
| 1 to 2 years | 43 | 32.3% |
| 3 to 4 years | 37 | 27.8% |
| 5 to 6 years | 22 | 16.5% |
| 7 to 8 years | 7 | 5.3% |
| 9 to 10 years | 10 | 7.6% |
| Over 10 years | 14 | 10.5% |

*Data collection: online survey*

Consistent with concurrent mixed-methods research approach, the online survey included both qualitative and quantitative elements. The qualitative component included open-ended questions, while the quantitative component consisted of closed-ended questions. To minimise unintended question-order effects (i.e. where the sequence of questions may inadvertently affect participants' responses), most open-ended questions were deliberately positioned at the beginning of each section (Dillman, Smyth, & Christian, 2014). This arrangement aimed to reduce potential bias arising from the specific language or concepts introduced in the subsequent Likert-scale questions. For example, one open-ended question asked, "When reflecting on matches with a larger crowd last season, how do you feel this affected you psychologically?" This was immediately followed by a Likert-scale question: "A large crowd presence increases how much pressure I place on myself during matches."

Survey questions were informed through discussions within the research team, and prior research in the context of crowd presence and available psychological support in football or team-sport (e.g., Mason & Lovell, 2000; McGreary et al., 2021; Hill et al., 2009; Hill & Shaw, 2013). The final online survey included 42 questions, with the first 15 focused on demographic data (i.e. age, assigned sex at birth, gender, ethnicity, and country of birth) and football-related background information (i.e. years competing, level of competition, primary position, and the largest approximate home and away crowd presence prior to and during the 2022-23 season, Figure 1).

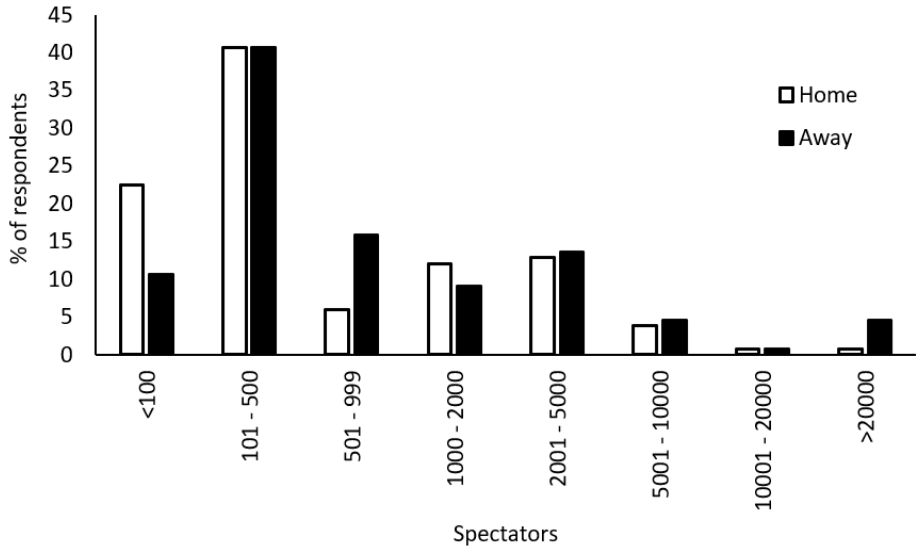


**Figure 1.** Approximate crowd number reported for home and away fixtures in the 22-23 season.

The remaining questions addressed three key themes and featured a mixture of open-ended questions to encourage free expression of thoughts, experiences, and emotions (Sheppard, 2024), alongside closed-ended Likert-scale questions. These themes were:

1. Perceptions of growth of the women's game (four open-ended questions).
2. Performance and wellbeing implications of this growth (three open-ended questions and ten Likert-scale questions).
3. Preparation and support in response to this growth (three open-ended questions and three Likert-scale questions).

The survey concluded with one open-ended question inviting respondents to share anything additional that had not been drawn upon. The survey was anticipated to take a maximum of 30 minutes to complete, with data collection occurring over 5 months (August to December 2023). A debrief statement was provided upon completion, including participants' unique codes and contact details for the primary researcher for data withdrawal purposes. No incentives were offered to participants for partaking in this project.

*Data analysis*

Data supporting this study's findings are available upon reasonable request from the corresponding author [DB], though they are not publicly accessible due to ethical restrictions (i.e. containing information that could compromise the privacy of research participants). In line with concurrent mixed methods design, qualitative and quantitative data strands were analysed separately before being integrated to provide a comprehensive perspective account of participants' experiences. First, Likert-scale responses were exported to Excel for calculation of descriptive statistics (%) to highlight trends that were both immediately interpretable and actionable, such as improving support structures for female athletes, in alignment with our pragmatic orientation. When combined with qualitative themes, this approach offers a holistic understanding of participants' experiences, grounded in both concrete data and lived realities.

Second, all responses to open-ended questions (i.e. qualitative data) were exported from Jisc Online Surveys platform into Microsoft Excel before being analysed using Braun and Clarke (2006) inductive thematic analysis approach. This consisted of six stages: data familiarisation, coding, searching for themes, reviewing themes, defining and naming themes, and producing a report. This approach began with data familiarisation, during which team members individually immersed themselves in the responses in attempt to understand the complexity of participants' experiences. During this stage, the

research team engaged in ongoing reflexive practice, critically examining how their respective positionalities, including experience within men's and women's football, could influence analytic decisions and interpretations of participants' accounts.

Next, researchers individually coded extracts of text that they felt were striking or significant in relation to helping address the research questions. This individual engagement allowed for the recognition of varied perspectives, aligning with pragmatism's emphasis on embracing complex human experiences through diverse interpretations. Subsequently, the research team met to share and critically interrogate their initial interpretations, fostering collaborative dialogue consistent with a pragmatic approach. These discussions functioned as a deliberate reflexive checkpoint, through which team members explicitly challenged one another's assumptions, positional influences, and analytic judgements to ensure interpretations remained grounded in participants' accounts. Through this reflexive and iterative process, the team collectively examined qualitative responses to identify recurring patterns (i.e. themes) across the dataset, allowing interpretations to evolve through sustained collaborative scrutiny.

Next, themes were refined through collective interpretation, with the research team exploring their meaning and agreeing on their naming and definition. Anonymised quotes were then selected to illustrate each theme. This stage was underpinned by reflexive dialogue, through which the team critically examined how their disciplinary backgrounds and experiential positions could shape both the framing of themes and the selection of illustrative excerpts. Across the broader analytic process, interpretations remained open to revision in response to continued team deliberation, reflecting pragmatism's emphasis on adaptability and responsiveness to the data. Interpretive decisions were also guided by consideration of how findings could inform practical strategies to better support female footballers, while drawing on relevant literature and theory to contextualise and deepen understanding. This reflexive and collaborative approach extended through drafting, revision, and production of the final report.

## Results

The analysis led to the identification of five themes; 1. Growth in the women's game, 2. Impact of crowd presence on performance, 3. Psychological impacts of heightened exposure, 4. Existing individual and group coping strategies, 5. Player wellbeing and support. These themes provide practical recommendations for stakeholders in women's sports, reinforcing the pragmatic goal of generating real-world actionable knowledge.

*Growth in the Women's Game*

The consensus from those surveyed was that the increased attention towards the women's game in recent years (e.g. increased television coverage and social media exposure) is connected to the Lionesses who were crowned UEFA Women's Euro 2022 Champions and reached the final in the 2023 FIFA Women's World Cup. Indeed, some of the participants described how this increased exposure has had a positive ripple effect on their respective *playing environments:*

> "[There's] a better atmosphere for the players and for the fans… More fans and tickets sold means that more income can be generated which will help the game improve. It'll help the professionalism of the game if more funding becomes available, which will benefit us as players in terms of the things we have access to (e.g. facilities, wages, more staff). More people will be likely to invest in the game as well if the viewing figures continue to increase which will only help the game and the players more." (**Participant 122, WC**)

The participants also described how this increased growth resulted in several positive *social outcomes* such as bringing communities together and being a positive role model to inspire future generations:

> "Seeing the younger generation grow and have the opportunities I never had at such an age is so enjoyable to watch... I never really had any female football role models since playing at 6 years old, now there's a tonne to look up too... For youngsters coming through, it's just amazing!... It's fantastic to see an increased support and participation of others who 2-3 years ago had never seen a women's football game." (**Participant 46, FA WNL Div One North East**)

Further, many participants shared a range of *personal outcomes* associated with increased growth such as "improved mental health" (**Participant 9**), "a sense of achievement" (**Participant 59**), "feeling valued" (**Participant 40**) and being "proud to be part of the process" (**Participant 17**). Several participants acknowledged various career prospects, though this was mainly in relation to opportunities it could provide for future footballers. For some, this was bittersweet due to the length of time the growth had taken:

> "It will give future generations a career path in football that I never had." (**Participant 88, FA WNL Div One South West**)
>
> "Having played in the first year of the WSL to playing in FA WNL now the growth of the game has been incredible. I almost wish I was 20 again and had my chance now with the backing the game is now receiving." (**Participant 28, FA WNL Div One Midlands**)

Whilst there were several positive environmental, social, and personal outcomes expressed in relation to the growth of the women's game, there were some drawbacks identified. In relation to their playing environment, improvements in clubs' infrastructure appeared to be inconsistent within and across leagues. For example, the participants expressed concerns that the growth in and "…attention isn't being followed with the appropriate investment of time, money, and resources" (**Participant 108**) and there is "limited help for clubs to learn how to grow their club and community" (**Participant 76**):

> "Where we play, there's limited car parking spaces for spectators... we are in a fairly rural area with limited transport links, so walking or cycling to a game becomes difficult for fans." (**Participant 60, FA WNL Div One South East**)
>
> "As a player at Tier 3, the teams with the biggest crowds are often those who have a more significant backing from their club/men's team and that greater level of marketing support. For example, [three well-known clubs] all have consistently high levels of support, as they have marketed it well and have created an environment that supporters go back to every week. The team I played for in the 2022/23 season received little support from the club - we played [a significant distance] away from the men's home ground and our average attendance was around 50-75. So, it has been a noticeable increase when we play away at teams who have the backing of their club, but often very small crowds at those who don't." (**Participant 107, FA WNL Northern Premier**)

They also referred to challenges in relation to balancing the heightened demands and expectations due to the increased professionalisation, with other responsibilities (e.g. full-time work):

> "It's great but does come with pressures on and off the pitch that at this level can be challenging as we work full-time." (**Participant 34, FA WNL Div One Midlands**)

Further, players also described some personal challenges experienced in relation to the game's growth. Increased awareness of the women's game has naturally increased attention toward players within stadiums, the mainstream media and across social media platforms. Some players conveyed a heightened sense of pressure in response to this: "not all the attention is positive…[and] increased attention has also led to increased exposure to negative people" (**Participant 85**), and there was particular reference to using it to "increase the stereotype of females not being able to play" (**Participant 26**). Indeed, 34.6% of participants agreed or strongly agreed that last season they 'received abuse from the crowd':

> "We play against teams that are affiliated to large clubs and share highlights over social media. These highlights are watched by thousands of people who post negative

> comments about players. Players are not trained to deal with it and have no one to help." (**Participant 29, FA WNL Div One Midlands**)
>
> "…with bigger crowds comes more things like hate whether that's on media or at games. I think it can affect you mentally sometimes depending on who you are, especially as you have more responsibilities being in a bigger public eye." (**Participant 119, WSL**)

Players also highlighted challenges in relation to fan and media engagement, noting that "fans expect the same level of interaction despite increasing crowds" (**Participant 112**). Players mentioned instances where they perceived a sense of entitlement from both the media, and some fans during post-game interactions. They conveyed that some of these expectations from the media and fans were overwhelming and felt there was a need for greater regulations in relation to this:

> "Because we have always interacted so well with the crowd, the expectations from them are now greater, e.g. time spent with crowds after games, asking for things, asking to attend events within their club…we could be supported with not having to please all crowd members after a game; as they grow, the demand post-game will be greater." (**Participant 38, WC**)

*Impact of Crowd Presence on Performance*

When exploring more specifically how increased crowd presence had impacted player's performance, 53.4% indicated that the size of the crowd did have an effect on their performance. 69.9% of participants agreed that when they played in front of a larger crowd, they tried to impress them more. The positive impacts on performance were generally discussed when asked about crowd presence at home games, and revolved around playing with an increased work rate (e.g. increased energy and intensity), heightened arousal (positively appraised), improved communication, a greater determination to win and a sense that it made them want to 'up their game':

> "It positively affected performance. I fully enjoyed it and buzzed off the atmosphere that they created… You want to impress the fans, so it gives you some extra motivation and energy to perform I think." (**Participant 122, WC**)
>
> "As a player knowing you've got a large crowd presence sets you right up for the game. It gives you an extra boost. You feel you have to perform to the best of your ability as always however more people are watching which puts pressure on you as a player, but personally I thrive off that. I think the bigger the crowd presence, the more positive effect it has on my performances." (**Participant 29, FA WNL Div One Midlands**)

When asked about the impact of increased crowd presence during away matches, some reported that it influenced the way that they played. Specifically, there was reference to players approaching games more conservatively:

> "It can be difficult when it is an away game. The fans often give you some grief and try to wind you up if they can but I kind of enjoy that as well… I think it makes me play safer and I am less likely to play risky or try things." (**Participant 122, WC**)

For others, it had more of a negative impact on their performance which was perceived to be more of a frequent occurrence amongst inexperienced players. By way of example:

> "The younger players get sucked in and get a little hot headed which leads to them getting yellow or red cards, all because a few people in the crowd said something antagonising." (**Participant 41, FA WNL Div One North**)

*Psychological Impacts of Increased Crowd Presence*

It was also found that increased crowd presence had various psychological implications for the players. For example, 66.9% of players agreed that a large crowd presence increased how much pressure they placed on themselves during matches. One participant highlighted how "pressure" is inherently part of the game, and "sports people have to thrive under [pressure]" (**Participant 104**).

Of notable interest was how different players perceived this pressure. Some players appraised this additional pressure in a positive way as it led to enhanced self-determination, increased "confidence" (**Participant 65**), and provoked positive emotions:

> "It gives me a thrill and as a player makes me want to play better for the big moments and games where there are more people are in attendance." (**Participant 1, FA WNL Div One South East**)
>
> "…The games are more exciting; I enjoy the pressure and I enjoy the reactions of the fans as it can be motivating when they spur the team on…" (**Participant 125, WC**)

However, for other players, the additional pressure was appraised negatively. Indeed, 58.7% agreed (or strongly agreed) that when they have played in front of a large crowd, they have felt more anxious. For some, this led them to "overthink every mistake" (**Participant 4**) and affected their ability to concentrate on the game:

> "I think it negatively impacted me psychologically as it made me more nervous and distracted me from my performance as I was overthinking how I was playing as I was desperate to play well." (**Participant 103, FA WNL Northern Premier**)
>
> "When you do make a mistake the bigger pressure on you can affect your mental state and concentration in the game." (**Participant 65, FA WNL Div One South East**)

> "Personally, I feel my performances dropped significantly due to having a bigger pressure to perform for the crowd rather than playing my own game under less pressure and being able to enjoy it." (**Participant 81, FA WNL Div One South West**)

The psychological implications of increased crowd presence were not limited to just those immediately preceding or during competition, though. Several players referred to overthinking following matchplay. In fact, 29.3% agreed or strongly agreed that a large crowd presence made them reflect more critically on their performance after the final whistle; highlighting potential negative implications which extend past the pitch and can be taken back into the home:

> "…often, I will scrutinise my performance a lot more because of the amount of people that witnessed it... [if] I played badly, this may lead to feelings of embarrassment or a missed opportunity to show what I can do." (**Participant 5, FA WNL Northern Premier**)
>
> "…I would look back and think do they think I did well, will that crap pass I made not make them come back and think women's football isn't worth watching." (**Participant 126, WC**)

*Existing Individual and Group Coping Strategies*

The majority (67.7%) of respondents agreed (or strongly agreed) that they believed "preparation for playing in front of a large crowd is important". When describing how they coped when performing under pressure, players drew upon a range of *individual* preparation strategies. For some, this included visualisation techniques, watching motivational videos, listening to music, writing down thoughts or diary-like approaches, using cue words, talking with team-mates, or using relaxation strategies (e.g. breathing techniques and meditation):

> "I always try to watch clips of where I've done something well the week leading up to a game, or a few days before because then I'm positively focused on things I've already done well and know I can replicate. I also think that focus is a massive thing when playing in front of big crowds and to regain focus after we score or we concede is crucial. To do this our team has a certain word that we will say to each other if we think we're losing focus in the game. That always helps too." (**Participant 60, FA WNL Div One South East**)
>
> "I meditate the night before and go to the gym the morning of the game. I write my thoughts down to help me manage what I'm feeling." (**Participant 107, FA WNL Northern Premier**)

> "I visualise my performance before the game (night and pre-match). For example, scoring a goal or pressing the defenders to make mistakes, creating chances etc." (**Participant 71, FA WNL Div One South West**)

Players also drew upon several *collective* preparation strategies, that were implemented as a team or by coaching staff prior to games in front of a large crowd. While consistency in pre-game preparation was often emphasised, some players also noted that the team's preparation was "a lot more precise and organised as a squad" (**Participant 2**) in the week preceding the match, the tone of team talks from coaching staff changed with "more belief put into the team talks" (**Participant 25**), and some worked specifically on communication in the build up to matches that were expected to be well-attended:

> "We just tried to focus on the football and not the crowds. I think we should have worked on preparing players more though." (**Participant 3, FA WNL Div One North**)
>
> "We would try to come up with other ways to communicate especially for larger crowds as we may struggle to hear each other and practice them during drills and training." (**Participant 84, FA WNL Div One South West**)

Some players also highlighted a lack of understanding regarding how they could improve their ability to cope with increased demands. In fact, just 22.6% agreed (or strongly agreed) to using coping strategies as part of their preparation process, underscoring the necessity for both player and coach education in relation to the use of coping strategies:

> "I don't use any [coping strategies] as I am unaware of what might help me." (**Participant 101, FA WNL Northern Premier**)
>
> "Coaches would talk about being prepared but not say how to prepare." (**Participant 114, FA WNL Northern Premier**)

*Player Wellbeing and Support*

Some findings regarding players' wellbeing and support were concerning, highlighting the need for player support. For example, 18% of participants agreed or strongly agreed that they had "thoughts of self-harm, depression, or experienced overwhelming negative emotions after playing a football match in the last season", with a further 6% responding that they neither agreed nor disagreed with the statement. Over half of the players who agreed with this statement (58.3%) were in the younger age bracket and aged under 21 years, with 25% aged between 22-25 years; somewhat supporting earlier notions that younger, less experienced players may find coping with these additional pressures more challenging than their more experienced counterparts:

> "My past club I wasn't supported from a mental side of it which is half the reason I moved clubs before the end of the season as I wasn't getting the support I needed. Playing nationally, I think the psychological wellbeing and support needs to massively increase and is sometimes forgotten about." (**Participant 39, FA WNL Northern Premier**)

Alarmingly, 65.4% stated that they had no opportunity for psychological or wellbeing support from a trained member of staff. A further 7.5% did not provide a response when asked 'what psychological support do you receive from your club?':

> "… During the previous seasons in the championship, I do not feel that I have had any support unless I have sought it out myself e.g. via the PFA or paid for it. Staff have not been as supportive or have rarely been able to point me in the right direction. There has been no sports psych, no psych support, no player care provisions at all, hardly any access to a safeguarding person, and no wellbeing support or considerations for how we players may be feeling or what we may need. Things are always football orientated and I have experienced many times where player welfare has not been prioritised. This season 23/24 in Tier 3 is an exception to this, and I could not fault the support available to me now but know this is unfortunately not on offer at all clubs." (**Participant 125, WC**)

For those who reported that they did not receive official psychological, or wellbeing support provided from the club, players often described seeking support from other individuals within the club for psychological support. For example, the players lent on their designated coaches, physiotherapists, or more senior players:

> "We could definitely be offered more professional psychological help rather than just a manager, coach or experienced player." (**Participant 15, FA WNL Div One Midlands**)

> "The coaches always mention they are available to talk if I wanted and I talk with my teammates, but we do not have a designated person for psychological help within the club or externally." (**Participant 5, FA WNL Northern Premier**)

Only 6.8% acknowledged having access to a safeguarding officer, who they could reach out to if they had any concerns when asked about available psychological and wellbeing support. Though there was some reference to uncertainty as to what support was available within clubs, and a need for this to be advertised more clearly.

> "Like chaplaincy and safeguarding but that's about it. We don't have a psychologist." (**Participant 131, WSL**)

> "Minimal, it's not very well marketed however if I really needed support, I'm sure there would be some available." (**Participant 93, FA WNL Southern Premier**)

Just 15% of respondents reported having regular opportunity to access to an accredited psychologist through their club, who was available to provide them with one-to-one support. Some players (5.3%) referred to having limited psychological support, for example understanding that "there is a psychologist on the men's side, but [we] have only seen them once" (**Participant 85**)**.** There was some reference to this support being in the form of infrequent group-based psychological support, such as "monthly mental health sessions every now and again" (**Participant 123**). There was also frequent reference to players "completing a survey every session based on our physical and mental health" (**Participant 125**) or "self-evaluation sheets to fill out (including performance and psychological)" (**Participant 55**), however with often no psychologist or individual within a player-support role, it is unclear how this data is interpreted and used to inform practice.

Importantly, 64.8% of the survey respondents agreed or strongly agreed that they "would like more psychological support from my club as the demands of the women's game continue to grow". Many players expanded on these suggestions, advocating for the appointment of a trained club psychologist and someone suitably qualified to support players in relation to their psychological needs.

> "Have a club psychologist. Have a dedicated professional; a team wouldn't be without a physio so why miss mental health." (**Participant 24, FA WNL Div One North**)

There were also suggestions around creating opportunities such as "open forum to raise concerns" (**Participant 114**) or an "anonymous ballot where [players] can ask questions and have them answered" (**Participant 83**). Further, there were several suggestions around clubs inviting trained psychologists to deliver mental skills workshops to provide players with a better understanding of how to "deal with pressure" (**Participant 123**):

> "Psychology sessions about stress, anxiety, [and] confidence to learn how to manage the types of emotions that may come up in games with bigger crowds." (**Participant 130, FA WNL Northern Premier**)

There were some additional suggestions focused more on prevention of psychological stress within the women's game. For example, players described a need to "approach [the] delivery of criticism differently" (**Participant 62**) and wanted to see clearer regulations and sanctions for those being abusive such as a "zero-tolerance policy for abuse" (**Participant 123**). There were also some suggestions around providing opportunities for players to get used to playing in front of a crowd such as for clubs to "allow for spectators at training sessions so that a crowd becomes normalised" (**Participant 123**), through either attempting to simulate environment demands or providing opportunities for crowds at training sessions.

## Discussion

This study sought to gain player perspectives on the contemporary demands of women's football in England, specifically in relation to the increased exposure seen in recent years. Additionally, it sought to understand what psychological support was currently available to female footballers currently residing in the top four leagues in England. In particular, we wanted to hear from players as to whether a) they felt additional support was needed, and b) how that support may look. Firstly, we acknowledge the many personal, social, environmental and performance benefits that were drawn upon by players in relation to the growth of the women's game. However, the results of the survey also highlighted the many challenges that female footballers face such as pressure/anxiety experienced, scrutiny and abuse received both online and within stadiums, and a lack of psychological support provisions, which key stakeholders need to consider for female athletes to thrive under the contemporary demands of the game.

As anticipated, players expressed a sense of increased pressure in relation to performing on a bigger stage. For some, this pressure was appraised positively and benefited performance. Others felt their performances were inhibited due to heightened anxiety. This aligns with the Theory of Challenge and Threat States in Athletes (TCTSA) (Jones et al., 2009) which explains that competitive stress can influence athletic performance either positively or negatively, dependent upon the demand and resource appraisal of that activity. If an athlete perceives the demands as dangerous (e.g. to esteem) and they are worried and/or uncertain about the outcome then they would be more likely to experience a threat state (Jones et al., 2009; Meijen et al., 2020). There was common reference throughout the survey regarding players feeling concerned about performing well in front of a bigger audience (both in stadiums and online), with explicit reference to the pressure they felt to give a good account of the women's game. Some players referred to being fearful of making a mistake as they felt it may contribute to gender-based prejudice and discrimination (i.e. "there are some people who will always see football is a "man's game" Participant 46) which they were very aware of within the women's game, which resulted in some reporting that this inhibited their performance or changed the way they played (e.g. more conservative performances).

The second key consideration of the TCTSA is resource appraisal, which is thought to encompass three inter-related constructs; self-efficacy, perceived control, and achievement goals (Jones et al., 2009). Self-efficacy, or an individual's belief in their ability to successfully complete a task, is largely influenced by past experiences (Bandura, 1997). This could help to explain why there was frequent reference throughout the survey to younger players often finding a large crowd presence more psychologically

challenging, and there being reference to performances being more affected in less experienced players compared to their more experienced peers (e.g. showing a lack of discipline). Additionally, Lazarus' (1999) cognitive appraisal theory emphasises the importance of effective coping operations, where no or ineffective coping resources can result in high threat appraisal. This is important given that only a small number of players involved in the study agreed that they used coping strategies, with many stating that they were not aware of what might help them. These findings demonstrate the need for players to have the opportunity to gain support in developing evidence-based coping strategies (e.g. relaxation techniques, imagery, thought-stopping) (Kent et al., 2018), to help maintain or optimise performance under pressure, particularly for those with limited experience in performing on a bigger stage and/or with greater perceived stakes.

Performing in front of more people resulted in many players ruminating over their performances, being more self-critical and overthinking mistakes. Some players referred to a sense of feeling "overwhelmed" with so many opinions. Some of these concerns again revolved around players feeling a sense of responsibility to positively showcase the women's game, at times referring to a worry of how their performances were perceived by the crowd and/or on social media, and some of the abuse that had been encountered particularly in relation to gender stereotypes. These findings reinforced the work of Fenton and colleagues (2023), highlighting the prevalence of gender-based discrimination and abuse experienced by women's footballers. Players proposed a need for media training and football clubs putting in place zero-tolerance policies with regard to abuse online. These findings again highlight the need to provide players with the opportunity for specialised psychological support, particularly where these negative implications were not exclusive to just on the pitch, and players reported overthinking or worrying long after a match had ended.

Of more concern, nearly a fifth of respondents stated that they had thoughts of self-harm, depression or experienced overwhelming negative emotions following a football match in the 2022-23 season; a stark statistic which emphasises the importance of ensuring appropriate psychological support systems are in place. As identified in Player Wellbeing and Support Theme, there was some indication that younger, less experienced players may be more negatively affected by the pressure than those more experienced, perhaps due to lower self-efficacy influenced by less experience (Bandura, 1997). Though this was not always the case; some in the older player age brackets who resided in the top tiers (i.e. WSL and WC) of women's football in England also agreed to the above statement. Importantly, 79.2% of those who had experienced thoughts of self-harm, depression or experienced negative overwhelming emotions, also stated that they had no psychological support, and stated that they

would like more psychological support. Of all respondents within the survey, nearly two thirds stated that they had no opportunity for psychological or wellbeing support (with a further 7.5% providing no response when asked about psychological support received). Whilst it may be expected that those residing in the higher leagues would receive greater levels of psychological and wellbeing support, it became apparent that these issues extend through to the highest level of the women's game (Harpur, 2024). Players referred to relying on a variety of informal sources of psychological support, namely from coaches, physiotherapists and more senior players. Coaches have long been considered a key source of psychological support, described as the "first line of defense" (Rees et al., 2012). This has increased interest in improving the reach and impact of psychology through non-professionals (i.e. coaches and support staff) and to improve their psychological literacy (Dean et al., 2022), particularly where risks of non-professionals sharing inaccurate psychological knowledge has been previously acknowledged (Murdoch, 2016). Whilst improved psychological literacy should be a priority for clubs, it should not replace the need for certified practitioners to deliver psychological support where financially and practically feasible. Importantly, 64.8% of respondents in the present survey wanted more psychological support as the demands of the women's game continue to grow.

The support players receive should also extend to helping players nearing the end of their football career, transitioning out of a player-role. Responses amongst older players referred to a little frustration and sadness that this growth was only occurring toward the end of their playing careers. We know that athletic retirement can often involve a significant change in identity, social support, questions over future career aspirations, and importantly risks to physical and mental health (Vorheis et al., 2023). Indeed, previous research focused on retired male professional footballers showed that 35% reported symptoms of anxiety and depression (Gouttebarge et al., 2015). In the only study to date that has examined mental health exclusively in retired professional female footballers (German First League), 9% of the respondents (n = 157) met the diagnosis criteria for clinical depression within the first 2 years of retirement (Prinz et al., 2016). However, more research is needed in relation to the challenges female footballers experience upon retirement across different leagues (e.g. in England) and the available support, particularly as female players may also face additional or different challenges to their male counterparts (e.g. financial positions on retirement due to lower salaries).

Whilst the best-case scenario would be that all clubs employ an accredited sports psychologist to work with and support players, which was encouraged by many of the survey respondents, it is acknowledged that this may not be feasible particularly outside of the WSL and WC, due to limited resources within some clubs. However, given the increased demands filtering through to the FA WNL

and the increased pressure and demands which players are facing, they should at a minimum have access to support staff who have engaged with psychological and/or mental health training resources, and at a minimum know where to sign-post players. This could be achieved through FA workshops, which could be made mandatory for some staff within clubs.

Additionally, as reported by several participants, a middle ground where group workshops (e.g. mental health support sessions) are delivered at different points throughout the season to help provide players with coping resources across all tiers could be a practicable and affordable solution to improve the available support. In some instances, it is likely where psychological support will be absent due to it being under-prioritised compared to other aspects of player support (e.g. strength and conditioning, nutrition). Research has highlighted some of the challenges associated with psychological provision within elite sport, for example, a focus on performance at the expense of everything else (McDougall et al., 2015). With this in mind, it is suggested that there needs to be greater education for football clubs on the importance of appropriate psychological provisions and understanding of both the physical and mental demands players face, particularly those placing great expectations on their players and expecting them to perform at professional (or semi-professional) standards. Further, the wellbeing services offered by the Professional Footballers Association, whom any male player that has been contracted to any English Football League club can access, are currently only available to female players who have played in the WSL. These services should be extended to those competing in high performance settings within the WC (as a priority) and FA WNL.

The concurrent mixed-methods survey design presents certain limitations, particularly in its inability to follow up on emergent and potentially significant participant responses. While the survey provided valuable breadth across players competing in different tiers, the use of an online questionnaire restricted opportunities to probe responses in greater depth or to explore nuanced experiences further. For instance, some participants referred to self-evaluation sheets that collected both performance and psychological data. However, it remains unclear how such data are interpreted, acted upon, or embedded within everyday practice at clubs. Therefore, future research would benefit from qualitative approaches, such as interviews or focus groups, to enable more detailed exploration of players' experiences. Additionally, hearing from coaches, support staff, and key decision-makers responsible for implementing player support systems would provide valuable insight into how psychological provision is prioritised, operationalised, and resourced within clubs. Capturing perspectives from both players and those involved in organisational decision-making would allow for

a more comprehensive understanding of how psychological support structures function in practice, and how they may be improved to meet the evolving demands of the women's game.

## Conclusion

As the popularity and standards of female football continue to grow, so too do the demands and expectations footballers are placed under. Whilst there are many benefits of the growth for players career prospects, the professionalisation of the sport, and personal benefits of gaining recognition for their achievements and positive impacts for the community, the additional psychological demands players now face should not be ignored. Key stakeholders in the women's game cannot expect female athletes to thrive (or continue) in environments where there is a disparity in resourcing, knowledge, and expert support. All of those working within a player facing role within football clubs within the top four tiers of women's football (and beyond) need to be aware of the psychological impacts of the increased attention and crowd presence alongside the other psychological demands of players' roles, they should also acknowledge players as individuals; where some may thrive under pressure, others may find some situations more challenging.

Football clubs need to consider what support they are offering their players, how this support is given (e.g. opportunity for one to ones), and who this support is given by (i.e. are they appropriately accredited). Where possible and resources allow, players should have regular opportunity to seek support from an accredited sports psychologist. Where this is not financially viable, clubs should seek practicable solutions with guidance from governing bodies (e.g. The FA) to provide the best possible player care in the absence of employing an accredited sports psychologist, for example through additional coach education and group workshops that can be delivered across the season in relation to mental health/wellbeing and to equip players with appropriate coping skills. Additionally, footballers, particularly residing in the WC, but also within Tiers 3 and 4, should be able to access the wellbeing support available through the Professional Footballers Association, where currently this is limited to current or previous WSL players, despite many within the WC and FA WNL being placed under demands and expectations comparable to professional football.

## Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to data restrictions, namely survey responses containing information that could compromise the anonymity and privacy of research participants.

## Conflicts of Interest

There are no relevant financial or non-financial competing interests to report.

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## Research Article

# Comparison of Resting Pilocarpine-Induced Sweat Sodium Concentration and Exercise-Induced Sweat Sodium Concentration in Highly Trained and Moderately Trained Athletes

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## Abstract

Resting sweat sodium concentration is commonly estimated using pilocarpine iontophoresis and a commercial sweat sodium analyzer (SSA), yet it may not reflect changes in sweat sodium during exercise. We compared pilocarpine-induced (resting) sweat sodium concentration with exercise-induced sweat sodium concentration during a 90-minute treadmill run. Twenty-five adults (10 males [40%], 15 females [60%]; age 36 ± 12.2 yrs) completed the trials. Before exercise, a resting sweat sample was induced on the upper forearm via pilocarpine iontophoresis and collected with a Macroduct® device, then analyzed on the SSA. Participants then ran for 90 minutes at moderate intensity (~65% heart-rate reserve). Exercise-induced sweat was collected on the inner forearm with Macroduct® collectors that were replaced at 15–30 minutes and at 90 minutes and analyzed on the SSA. Participants were categorized into highly trained and moderately trained athletes based on their average treadmill speed during the trial (average speed < 6.5 mph = moderately trained, average speed >6.5 mph = highly trained). Mean (±SD) resting pilocarpine-induced sodium concentration was 51 ± 19 mM. Exercise-induced sweat sodium concentration averaged 50 ± 22 mM at 15–30 minutes and 57 ± 23 mM at 90 minutes, with no differences versus pilocarpine values (p=0.84 and p=0.09, respectively). Subgroup trends indicated greater divergence in moderately trained participants, particularly moderately trained females, who showed a difference between the pilocarpine-induced values and the 90-minute exercise-induced values (p=0.033). Although group means were similar at rest and during exercise, meaningful individual and subgroup variability was observed. Resting pilocarpine-induced sweat sodium may not reliably represent exercise-induced sweat sodium for all athletes, especially moderately trained females, highlighting the need for exercise-specific measurements when developing hydration and electrolyte replacement strategies.

**Keywords:** exercise, hydration, pilocarpine, sodium concentration

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## Introduction

Sweat plays a crucial role in the body for regulating core temperature through heat dissipation and regulating electrolyte balance especially during exercise (Casa et al., 2000). Physiological and environmental factors such as heart rate, sweat rate, core temperature, and relative humidity can influence the rate and composition of sodium excretion through sweat during physical activity (Baker, 2017). Understanding these factors is essential for developing effective hydration strategies and optimizing athletic performance. Hydrating properly helps to regulate body temperature, support cardiovascular function, and maintains plasma volume (Murray, 2007). Imbalances in sodium levels can lead to health and performance issues in athletes, such as hyponatremia, characterized as abnormally low levels of sodium, or dehydration which could cause impairments in physical performance and pose serious health risks (Cheuvront et al., 2003).

Understanding an individual's sweat sodium concentration is crucial in developing a personalized hydration strategy which is shown to reduce hydration-related issues. One method to determine sweat sodium concentration is through pilocarpine-induced collection of a resting sweat sample that is then tested using a sweat sodium analyzer (SSA). However, this test does not allow a user to determine changes in sweat sodium concentration during exercise. Exercise-induced sweat sodium concentrations are typically determined by patch testing and subsequent sweat analysis (Baker, 2019). Discrepancies between the pilocarpine-induced and exercise-based methods have raised questions about the accuracy of assessing sodium loss during physical activity by using a pilocarpine iontophoresis test as a proxy for measured sodium loss during exercise.

There are three main sweat glands that mediate the physiological response of sweating. These sweat glands include eccrine, apocrine, and apoeccrine glands, with eccrine glands being the primary contributors to thermoregulatory sweating. Eccrine sweat is comprised of mainly water and sodium chloride, but it contains other electrolytes in smaller concentrations as well (Baker, 2019). Exercise-induced sweating starts from an increase in core temperature, which activates sympathetic cholinergic pathways that stimulate the eccrine glands (Baker, 2019). Unlike exercise-induced sweat, pilocarpine-induced sweat is activated by a cholinergic agent called pilocarpine nitrate that binds to the muscarinic receptors of eccrine sweat glands to induce sweat production through a small electric current that pushes the chemical agent into the skin (Basu et al., 2013).

When comparing pilocarpine-induced sweat and exercise-induced sweat, pilocarpine iontophoresis allows sweat secretion to only be induced from local cholinergic stimulation of sweat glands, while

exercise-induced sweat is stimulated from other local and central mediators such as adrenergic stimulation, neuromodulators, and the exercise pressor reflex (Baker, 2017). Previous research has shown differences between exercise-induced and pilocarpine-induced sweat when cycling at 75% functional power threshold power (Harris et al., 2024). The purpose of this study aims to compare the sodium concentration between exercise-induced sweat from a running trial and pilocarpine-induced sweat. Through analyzing and understanding the differences in sodium concentrations between these two conditions, the aim is to provide insights into the variability of sweat composition during exercise and to improve methods for assessing and managing electrolyte balance in athletes and physically active individuals.

## Methods

*Participants*

This study recruited 25 healthy adults (10 [40%] males, 15 [60%] females; age 36 ± 12.2 yrs) from 19 years of age to 67 years of age through fliers and internet notices at Cleveland State University for a total of 25 trials completed. Participants were screened to ensure that a 90-minute treadmill running protocol could be safely performed. A PAR-Q+ questionnaire (Physical Activity Readiness Questionnaire) was used for screening. Study exclusion criteria included any positive answers to the PAR-Q+, where exercise was determined to be high risk for the subject. The protocol was approved by the Institutional Review Board (IRB; IRB-FY2022-75) of Cleveland State University and all subjects provided written informed consent; participant characteristics can be found in Table 1.

**Table 1**. Baseline information of participants

| **Characteristic** | **Mean +/- SD** | **Range (Min to Max)** |
|---|---|---|
| Age (yr) | 36 ± 12 | 19 to 67 |
| Weight (kg) | 73.4 ± 18.13 | 51.7 to 121.6 |
| Height (m) | 1.72 ± 0.09 | 1.57 to 1.85 |
| %Male | 44% | |
| %Female | 56% | |
| Average Heart Rate (bpm) | 148 ± 7 | 133 to 159 |
| Average Body Temperature (F) | 100 ± 2 | 96.1 to 102 |
| Average Room Temperature (F) | 74 ± 2 | 70.4 to 77.5 |
| Average Room Humidity (%) | 31 ± 13 | 17.5 to 65.1 |

*Resting Sweat Collection*

Before the onset of exercise, a resting sweat sample was collected from each participant using pilocarpine iontophoresis. The method of using pilocarpine iontophoresis involves applying a small

electrical current to drive the sweat-inducing agent, pilocarpine, into the skin to stimulate sweat production on the upper forearm. The pilocarpine sweat gels contain a concentration of 0.5% Pilocarpine Nitrate, Agar, Methylparaben, and Propylparaben (Precision Hydration, Christchurch, United Kingdom). The upper forearm was first cleaned with distilled water, then the pilocarpine sweat gel discs were added to the electrodes. The electrodes were attached to the subjects' upper forearm, and the sweat inducer was activated. The sweat induction was conducted at 1.5 mA for five minutes until iontophoresis was completed, and the electrodes could be taken off of the subject, per manufacturer guidelines. From this procedure, sweat was induced under the electrodes and was collected; the pilocarpine sweat gels, electrodes, and sweat inducer can be seen below in Figure 1.

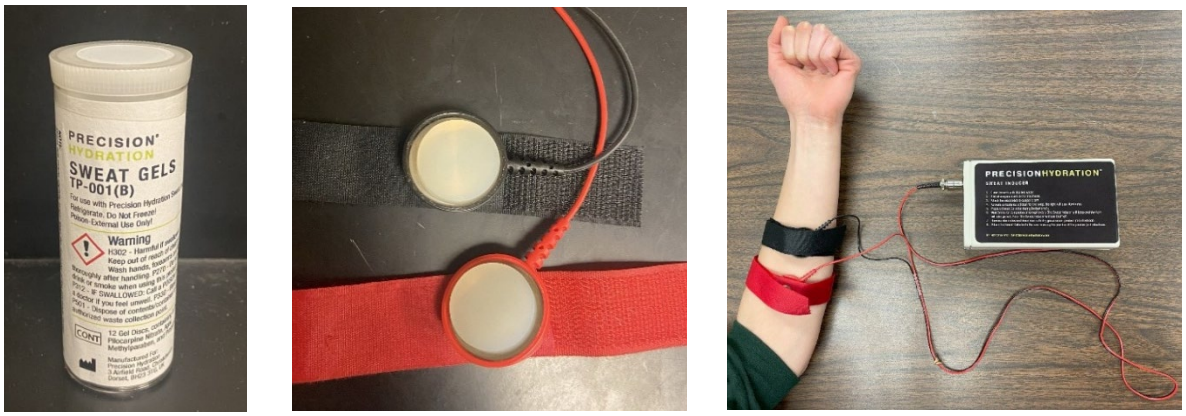


**Figure 1.** Precision Hydration sweat gels, pilocarpine sweat gel discs added to the electrodes, and electrodes attached to the sweat inducer and the forearm of the subject.

The sweat was then collected in a Macroduct® Sweat Collector (Wescor, Logan, Utah), which is solely used to collect sweat, and was applied firmly to the forearm to eliminate any air gaps. The Macroduct® Sweat Collector is a disposable plastic device with a concave undersurface and a small opening at the apex of the convex surface that leads to a 0.64 mm small-bore plastic tubing coiled into a spiral. Hydraulic pressure is created when sweat is secreted from the sweat glands which allows sweat to flow up and be collected in the plastic tubing. The volume of the spiral collection tube is approximately 85 microliters which is a suitable amount to analyze sweat. The subject's skin was wiped clean with sterile gauze and deionized water before placing the Macroduct®. Once the Macroduct® tubing had collected enough volume, it was removed through use of a blunt needle and cut from the subject's arm. The Macroduct® collector must remain on the forearm until the plastic tube is removed at its attachment point. The Macroduct® on a subject's forearm can be seen in Figure 2 below. Collected sweat was analyzed using a laboratory-quality sweat sodium analyzer (Precision Hydration, conductivity-based measurement) (Dyshko et al., 2024).

**Figure 2.** Macroduct® sweat collector on a subject's forearm. The clear cover was removed to display the spiral of the collecting tube.

*Exercise Protocol*

A Macroduct® sweat collector was placed on the inner arm of the subject, and the subject started running at a moderate intensity for 90 minutes on the treadmill, targeting to be at approximately 65% of their heart rate reserve (Chuna et al., 2010). The Macroduct® Sweat Collector was used to collect exercise-induced sweat. The sweat collector was taken off of the subject's inner forearm and replaced after 15 to 30 minutes and analyzed on the SSA to determine the sodium concentration. After 90 minutes, the second sweat collector was taken off of the subject and analyzed on the SSA. Heart rate, body temperature, room temperature, and relative humidity were also recorded during the exercise session. Heart rate was measured through a Polar Heart Rate Monitor (Polar H10, Hofwisenstr, Switzerland), body temperature was measured through a Core Body Temperature Monitor (CORE1, Hofwisenstr, Switzerland). Room temperature and humidity were measured with a ThermoPro Digital Hygrometer Thermometer and Humidity Meter (ThermaPro TP50, Lawrenceville, Georgia).

*Data Analysis*

All data processing, visualization, and statistical analyses were performed in R (RStudio, v4.5.2, R Core Team, Vienna, Austria). Participants were categorized into four characterization groups based on fitness level and sex: Highly Trained Female, Highly Trained Male, Moderately Trained Female, and Moderately Trained Male. The male and female groups were categorized based on the average treadmill speed during the trial. A treadmill speed greater than or equal to 6.5 mph was categorized

as a highly trained participant while a treadmill speed less than 6.5 mph was categorized as a moderately trained participant (Gordon et al., 2017). For each group, sweat sodium concentration was evaluated across three sweat collection conditions: pilocarpine-induced, 15–30-minute exercise-induced, and 90-minute exercise-induced.

For each group, descriptive statistics were calculated and reported as mean ± standard deviation (SD). To evaluate whether exercise-induced sweat sodium differed from pilocarpine-induced sweat sodium within each participant characterization group, paired-sample, two-tailed t-tests were conducted for the comparisons of pilocarpine-induced sweat versus 15–30-minute exercise-induced sweat and pilocarpine-induced sweat versus 90-minute exercise-induced sweat. These tests were performed separately within each group, treating each row as a paired observation across sweat collection conditions. Statistical significance was defined as $p < 0.05$.

## Results

Average pilocarpine-induced resting sodium concentration was 51 ± 19 mM; after 15-30 minutes of exercise, the average exercise-induced sodium concentration was 50 ± 22 mM, and after 90 minutes of exercise, the average exercise-induced sodium concentration was 57 ± 23 mM. There was no difference in sweat sodium concentration at different exercise times compared to the pilocarpine-induced values (15–30-minute exercise-induced vs. pilocarpine-induced p-value= 0.84, 90-minute exercise-induced vs pilocarpine-induced p-value= 0.09) (Figure 3).

When comparing between fitness level and sex, differences were evident. After 90 minutes of exercise, the sweat sodium values in the Moderately Trained Female subgroup were higher than the pilocarpine-induced sweat sodium values (p-value = 0.033). No differences were observed in other subgroups when comparing pilocarpine-induced sweat sodium values and 15-30 minutes exercise-induced and 90-minute exercise-induced sweat sodium values. To assess the level of agreement between the pilocarpine-induced and exercise-induced measurements in each subgroup, intraclass correlation coefficients (ICC) were assessed. Additionally, the 95% confidence interval (CI) was evaluated (shown in Table 2).

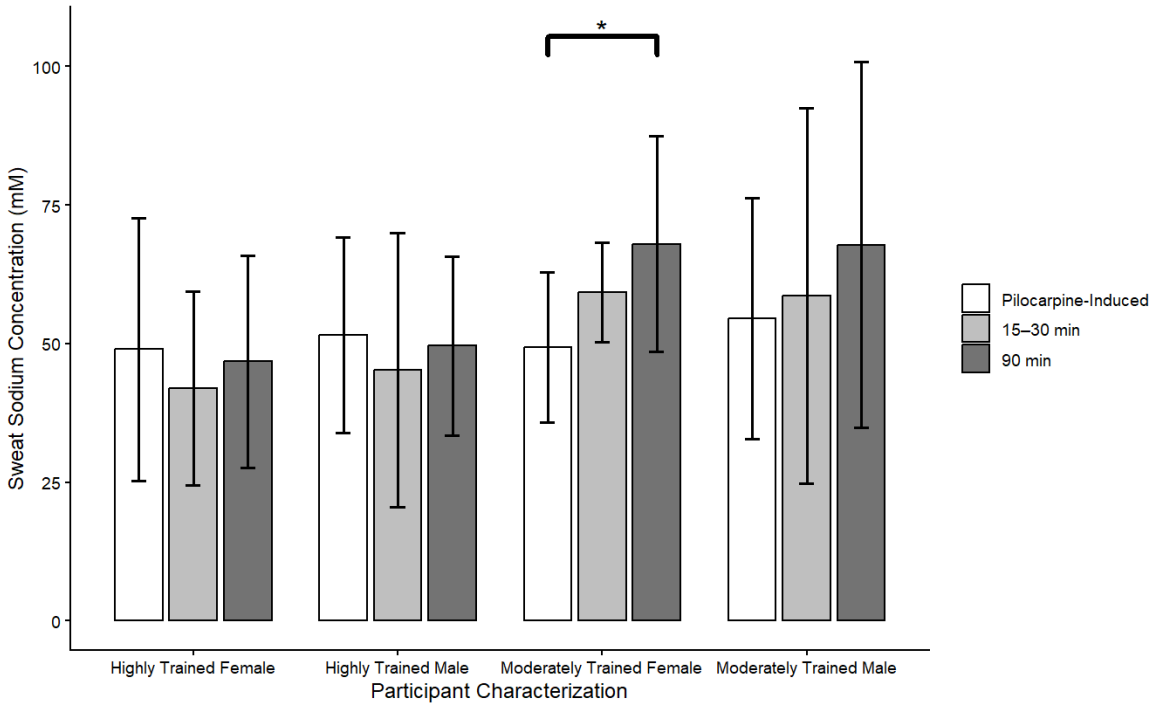


**Figure 3.** Comparison of pilocarpine-induced and exercise-induced sweat sodium concentrations between Highly Trained Females, Highly Trained Males, Moderately Trained Females, and Moderately Trained Males. * indicates $p<0.05$.

**Table 2.** Intraclass correlation coefficient (ICC), 95% confidence interval (CI), and p-values when comparing pilocarpine-induced and exercise-induced sweat sodium concentrations between Highly Trained Females, Highly Trained Males, Moderately Trained Females, and Moderately Trained Males.

| | ICC | 95% CI | P-value |
|---|---|---|---|
| Highly Trained Female Pilocarpine-induced vs 15-30 minutes | 0.84 | 0.41 - 0.96 | 0.077 |
| Highly Trained Female Pilocarpine-induced vs 90 minutes | 0.94 | 0.78 - 0.99 | 0.4 |
| Highly Trained Male Pilocarpine-induced vs 15-30 minutes | 0.9 | 0.36 - 0.99 | 0.16 |
| Highly Trained Male Pilocarpine-induced vs 90 minutes | 0.9 | 0.36 - 0.99 | 0.61 |
| Moderately Trained Female Pilocarpine-induced vs 15-30 minutes | 0.42 | -0.19 – 0.88 | 0.075 |
| Moderately Trained Female Pilocarpine-induced vs 90 minutes | 0.36 | -0.17 – 0.85 | 0.033 |
| Moderately Trained Male Pilocarpine-induced vs 15-30 minutes | 0.68 | -0.44 – 0.96 | 0.73 |
| Moderately Trained Male Pilocarpine-induced vs 90 minutes | 0.52 | -0.38 – 0.93 | 0.33 |

ICC, intraclass correlation coefficient; CI, confidence interval.

Figure 4 evaluates the agreement between the pilocarpine-induced and exercise-induced sweat sodium concentrations by plotting each subgroup and timepoint. If the two collection methods yielded the same sweat sodium concentrations, the data would fall directly on the line of identity (y=x). Deviations from this line reflect disagreement between the pilocarpine-induced and exercise-induced measurements. Points located above the line indicate that exercise-induced sweat sodium exceeded the corresponding pilocarpine-induced value, while points below the line indicate that exercise-induced values were lower than pilocarpine-induced values. In the highly trained subgroups, the data cluster closely along the line of identity, suggesting stronger agreement between these methods. However, larger deviations from the line of identity are observed in the moderately trained subgroups, particularly the moderately trained females. This indicated a poorer agreement between these methods. This shows how pilocarpine-induced sweat sodium concentrations may not represent exercise-induced sweat sodium concentrations in moderately trained athletes.

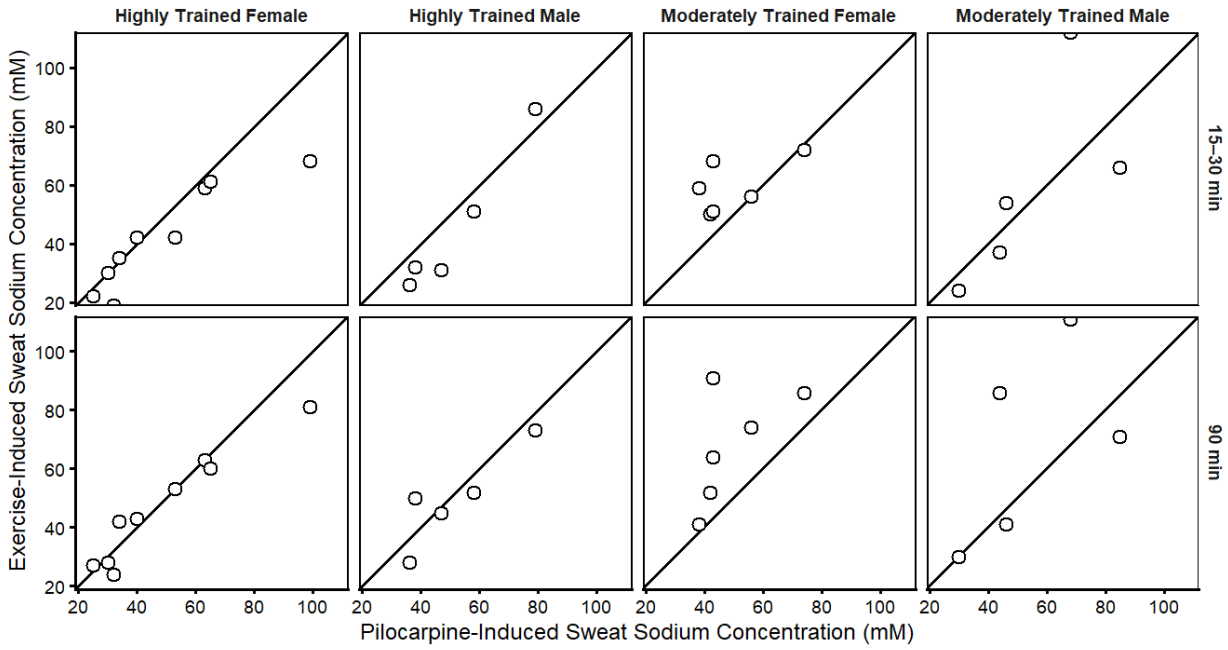


**Figure 4.** Pilocarpine-induced and exercise-induced sweat sodium concentrations agreement between Highly Trained Females, Highly Trained Males, Moderately Trained Females, and Moderately Trained Males. The line of identity (y=x) is shown as a reference.

## Discussion

The present study examined the differences between pilocarpine-induced and exercise-induced sweat to assess whether resting sweat measurements could reliably be used to predict sweat sodium levels during a 90-minute treadmill run. Among the entire trial, pilocarpine-induced values were similar to exercise-induced values at 15-30 minutes and at 90-minutes, showing no statistical significance when all participants were considered together (p-value = 0.84 and p-value = 0.09, respectfully). These findings indicate that pilocarpine iontophoresis may approximate average sweat sodium concentration correctly across an entire population of runners but may not capture differences between subgroups of fitness level and sex.

Despite the lack of significant differences in group means, subgroup analyses indicate that pilocarpine-induced to exercise-induced sweat sodium concentrations are not uniform across all fitness levels. In particular, moderately trained females demonstrated the greatest divergence, with a statistically significant difference between pilocarpine-induced values and 90-minute exercise-induced values (p-value = 0.033). This supports the conclusion that pilocarpine-induced sweat sodium may be less reliable for exercise-induced sodium loss in moderately fit individuals. Agreement analyses further reinforce this. Intraclass correlation coefficients (ICC) were used to qualify agreement between pilocarpine-induced and exercise-induced measurements within each fitness level and sex. In the highly trained subgroups, ICC values were generally high (0.84 – 0.94 in females and 0.90 in males), suggesting a stronger agreement between resting and exercise-induced values in these participants. In contrast, agreement between moderately trained athletes were substantially lower (0.36 – 0.42 for females and 0.52 – 0.68 for males). This is consistent with greater variability and poorer correspondence between the sweat collection methods. Collectively, these results indicate that the utility of pilocarpine-induced sweat testing methods depends on athlete characteristics and exercise duration.

Differences between pilocarpine-induced and exercise-induced sweat sodium concentrations have meaningful performance implications when sweat testing is used as a guide to individualized hydration strategies. If a pilocarpine-induced test underestimates an athlete's exercise-induced sweat sodium concentration, sodium losses during training or competition may be under-replaced. In this case, an athlete who replaces primarily with water or low-sodium fluids may develop a progressive dilution of extracellular sodium and become susceptible to hyponatremia, characterized by a low amount of sodium in the bloodstream (O'Neal et al., 2020). Additionally, hyponatremia can result in symptoms such as headache, nausea, dizziness, and impaired performance (Oracio et al., 2000). Conversely, when

pilocarpine-induced values exceed exercise-induced values, athletes may over-replace sodium, which can cause negative effects such as hypertension if the sodium intake is chronically high (Stachenfeld et al., 2008). These findings support the recommendation that exercise-specific sweat sampling may be warranted when individualized sodium replacement recommendations are needed, especially for moderately trained athletes and for longer-duration sessions.

This study used a single moderate-intensity running protocol (65% heart-rate reserve) and did not take into consideration how results may differ across intensities, exercise type, or environmental conditions (Harris et al., 2026). Additionally, the relatively small sample size (n = 25) limits the statistical power of the analyses and restricts the generalizability of the findings, particularly for subgroup comparisons based on sex and fitness level. Future studies should investigate larger, more diverse populations and account for these additional factors along with menstrual cycle phase and hydration status. Tracking these factors may give more insight into how the sweat sodium concentration changes over the course of the trial and compares to the pilocarpine-induced sweat. Having a larger sample size would allow for the study to be validated.

*Conclusion*

This study evaluates whether a resting pilocarpine test can be used in place of an exercise-induced sweat sodium test through evaluating pilocarpine-induced sweat sodium against exercise-induced sweat sodium collected during a 90-minute moderate intensity treadmill run, with additional categorization between fitness level and sex. While mean values across the full study were comparable between pilocarpine-induced and exercise-induced at both 15–30 minutes and 90 minutes, subgroup analyses demonstrated that agreement is not uniform, with a significant difference observed in the moderately trained female subgroup at 90 minutes. These discrepancies indicate that pilocarpine-induced sweat testing may not accurately reflect dynamic physiological responses during prolonged physical activity. The results emphasize that relying solely on resting pilocarpine-induced sweat sodium concentrations could lead to either underestimation or overestimation of sodium loss during exercise, which would impact hydration and electrolyte replacement strategies. Therefore, exercise-induced sweat should be used to accurately determine sweat sodium values to optimize performance and recovery. Future research should aim to validate these findings in larger and more diverse populations while controlling additional physiological and environmental factors.

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## Research Article

# "We're All Dads Here": The Impact of Transitions on Coach-Athlete Relationships in British Ski Racing Academies

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Running Title: Impact of Transition on coach-athlete relationship

## Abstract

The aim of this study was to examine how transitions within British ski racing academies impact coach-athlete relationships. British ski academies constitute a previously unstudied setting and are unique in that coaches and athletes live together in the academy house, leaving little separation between the training and home environments. The term "transitions" in the context of this paper refers to both longitudinal transition of athletes through age and competitive stage, and lateral transition between the training and home environments in the residential academies: the 2 transitions noted here were the initial focuses of this research. This study conducted semi-structured interviews with 7 professional coaches drawn from 2 British-run ski academies who operate European-based residential programmes. The research findings identified 2 additional transitions as significant: these were athletes' longitudinal transition from UK training to full-time residential academy; and the lateral transition between training and race settings. The key findings within these transitions were the coaches' role in facilitating athletes' initial integration into academy; the significant impact that lateral transitions (between training and home/training and race) have on the coach-athlete relationship; and the role of gender in the coach-athlete relationship specifically in the transition from training to race settings. There were novel results from this research which reveal the scale of coaches' pastoral role in a talent development environment where coaches and athletes live together. This study has implications for coach education provision in British ski racing and has resulted in consultation with Snowsport Scotland on ways in which to improve coaches' education and wellbeing to enhance gender equity in coaching pathways.

**Keywords:** alpine ski racing, coach-athlete relationship, high-performance coaching, talent development environments, transition.

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# Introduction

Ski racing academies are a particularly intensive model of sports academy, as in these settings, coaches and athletes live together within an academy house. In such settings, the coach's position becomes more than that of an instructor, coaches become embedded in athletes' personal development as de facto parents (Roux et al., 2022). This unique setting provides an overlap in areas of study, incorporating the importance of the coach-athlete relationship to youth athletes and to the context of transitional and developmental phases of an athletic career. While there are several studies that discuss the importance and key characteristics of the coach-athlete relationship, there is a dearth of research focusing on the impact of transition on this relationship, particularly in the sports academy setting, and particularly with regards to the coaches' perspective (Olusoga et al., 2021; Jowett & Poczwardowski, 2007).

The model within which this paper will situate discussion of transitions is the lifespan model as proposed by Wylleman and colleagues (2012). This model built upon the initial talent development transition model proposed by Bloom which placed talent development in the context of 3 stages: initiation; development; and mastery (Bloom, 1985). Wylleman and colleagues' perspective offers a more holistic approach to these transitions, as their lifespan model mapped Bloom's original stages onto 4 development domains: athletic; psychological; psychosocial; and academic or vocational (Wylleman et al., 2012). The transition phases and domains that will be discussed in the present research align with those proposed by Wylleman et al. (2012). Transition in this context refers not only to the longitudinal transition through the athlete's age or training stage, but also to the lateral transition in external environment (i.e., between training environment and academy home).

Transitions in the coach-athlete relationship come not only from external influences, but from the evolving nature of the relationship itself (Philippe et al., 2011). Such relational changes come naturally and occur routinely in academy settings as athletes progress through the phases of talent development, reflecting Bloom's proposed progressions through initiation and development to mastery (Wylleman et al., 2012; Bloom, 1985). Many athletes cite their relationships with their coaches as the most influential in either facilitating or jeopardising this progression, and thus the coach-athlete relationship becomes a lynchpin for athletes' development and sense of security in transitional phases throughout their careers (Orione & de Souza Fleith, 2022).

As is noted by Wylleman et al. (2012), athletes age and progress through competitive stages, add additional stressors outside of the sporting domain (i.e., academic pressures or interpersonal relationships), and the management of these stressors has the potential to impact performance (Wylleman et al., 2012). Santos and colleagues (2018) highlighted the importance of social support - and specifically the coach-athlete relationship - in helping athletes to cope with these non-sporting issues, demonstrating through their case study how successful long-term coach-athlete relationships can provide support through transitional and even traumatic periods in the athlete's life (Santos et al., 2018). This is what we see emulated in the long-term relationships established in ski racing academies. The successful coach-athlete relationship not only enhances an athlete's technical performance and results, but also supports their psychological and emotional well-being, and as such clearly intertwines with the development domains described in Wylleman's lifespan model (Jowett, 2017; Jowett & Poczwardowski, 2007).

The emotional impact of the coach-athlete relationship is especially formative when it comes to young athletes. Davis and Jowett (2014, p. 1457) observed that coaches act as "a safe haven, and a secure base" for athletes: the emphasis we see here on care as a key component to the coach-athlete relationship was also noted in Hampson and Jowett's (2014) research on coaching leadership styles, finding that athletes placed a high value on interpersonal relations and specified care, support, and trust as key components (Davis & Jowett, 2014; Hampson & Jowett, 2014). These characteristics become particularly relevant in the current research context as we consider how the coach-athlete relationship may be impacted by the close proximity entailed by coaches and athletes living together. Roux and colleagues (2022) posited that in residential sports academies, where athletes are often away from home for long training blocks, coaches take on central roles not only in facilitating sporting progression but in supporting athletes' personal development (Roux et al., 2022). Similarly, Collins and MacNamara (2018) emphasised the importance of the coach's influence in mitigating identity foreclosure (Collins & MacNamara, 2018). Identity foreclosure is a psychological phenomenon in which an athlete commits solely to one sport (in this case, ski racing) and in so doing, closes off other potential avenues for development (Petitpas & France, 2010; Collins & MacNamara, 2018). The role of coaches in mitigating foreclosure links back to Wylleman and colleagues' (2012) holistic view of athlete transition and the understanding of non-sporting domains as key contributors to athletes' performance and the sustainability of their sporting development (Wylleman et al., 2012). Fawver et al. (2020) also emphasised the risks of identity foreclosure with specific reference to the ski academy environment, where the external stressors of peers, parents, and the notable financial implications of academy training may increase the pressure on athletes to succeed in their sport (Fawver et al., 2020).

Thus again, the coach-athlete relationship appears as a pillar in providing emotional and psychosocial support to the athlete and helping to alleviate some of the pressures that may detract from athletes' performance and their psychological well-being.

However, alongside the strengths of successful coach-athlete relationships, it is important to also acknowledge the pressures that can come with developing such significant relationships in such intensive settings. The supportive role of the coach often leaves little capacity for coaches to address their own stresses or relieve the pressure of being the "safe haven" for athletes, particularly in environments where there is little time spent apart from said athletes (Davis & Jowett, 2014). As noted by Olusoga and colleagues (2021), the pressure of sustaining high-performing coach-athlete relationships is but one source of stress in the coaching role and can contribute to coaches' experience of burnout. Olusoga et al (2021) also highlighted that the majority of coach-athlete relationship and coaching stress research has focused on the athlete's perception and experience, while sidelining the coach themselves – a research gap addressed by this study's focus on coaches' experience of their relationships (Olusoga et al., 2021).

As noted, while there has been research conducted on the importance of the coach-athlete relationship and its role in intensive talent development settings and in ski racing, there remains little study of sporting development environments in which coaches and athletes live with one another and therefore minimal insight into how such contexts may impact the coach-athlete relationship. The closest comparison to this type of residential development environment is boarding schools: settings that generate similarly intensive development and limited or insular social interactions (Pfeiffer et al., 2016). The research found that boarding school students felt more supported by teachers than parents and noted that peer socialisation also took on greater influence in students' development (Pfeiffer et al., 2016; James, 2023). These observations are comparable to ski racing academies as, in both settings, non-parental figures such as teachers or coaches take on more significant roles in youth development than would normally occur, and therefore the strength of those supplementary relationships may become more influential for both performance and overall well-being. Collectively, the purpose of this research was to explore the coach-athlete relationship in the context of residential ski racing academies, and specifically to examine the ways in which transitions within these academies can impact and influence coach-athlete relationships.

# Methods

*Research Design*

This is a qualitative study using a single-case research design, as the research focuses on understanding relationships and personal coaching experiences, areas which benefit more from interview and qualitative evidence than quantitative data (Braun & Clarke, 2013). In the case of this study, the focus is on the changes that occur in the coach-athlete relationship in relation to social or environmental transition (Barker et al., 2011). Barker and colleagues (2011) also noted that single-case designs are of particular benefit to applied practitioners in generating an evidence base for changes in behaviour or performance in relation to manipulated variables and for identifying potential interventions in a sports setting, thus making it a suitable study design choice for this project in its aim to provide insight to practitioners. While typically the single-case study design relies on a single participant, this participant can be conceptually expanded to encompass a participatory group which then constitutes the single case: in this instance, the case is a single demographic group of alpine ski coaches (Barker et al., 2011). The group is composed of 7 professional ski coaches who were drawn from 2 ski racing academies and all subject to the same inclusion criteria. The simplicity and adaptability of the design also makes for a readily replicable project in different sports or talent development settings (Albers & Kratochwill, 2010).

*Participants & Sampling*

Participants were selected using purposive sampling, a technique in which participants are selected based on specific inclusion criteria (Jones, 2022). In this study, there were 2 crucial metrics for coach inclusion beyond their employment in a participating ski academy: coaches must have worked with their participating ski academy for at least 1 full season prior to acceptance to the project; and coaches must hold a minimum of a UKCP Alpine Level 2 coaching qualification or equivalent. These requirements aligned with the protocols of purposive sampling and ensured that coaches had a level of coaching education and experience that would allow them to reflect on their practice and relationships with athletes (Palinkas et al., 2015; Jones, 2022). There are limitations to the generalisability of findings drawn from purposive sampling, however in the context of this research, the technique is the best suited to provide the depth of insight required to make the research relevant and valuable to practitioners (Palinkas et al., 2015).

Ethical approval for this project was obtained (September 2023) before contact was made with 4 academies via email: 2 academies expressed interest in participating. Individual meetings were then

conducted with each head of academy to discuss their involvement and to learn more about their coaching teams in order to determine which coaches would be suitable for selection. After these meetings, contact was made with individual coaches, all coaches were provided with Participant Information Sheets and provide written informed consent prior to interviews. Four coaches were sampled from Academy 1, and 3 coaches were sampled from Academy 2 (n = 7). All participants held at least UKCP Level 2 coaching qualifications and all had been working with their participating academy for a minimum of 2 years prior to interview – surpassing the time-in-post requirement for inclusion. Both participating academies are British-run but operate European-based residential programmes, and work with a broad age range of athletes (12 to 22 years old). Table 1 provides some key demographic details about each of the participants allow for cross-referencing between quotations and participant (quotes will be attributed to a participant number: i.e., Participant 1, Participant 2).

**Table 1.** Participant Demographics

| Participant | Years of Experience | Nationality | Location of Programme | Gender | Age | Academy |
|---|---|---|---|---|---|---|
| 1 | 10 | British | Italy | Male | 27 | 1 |
| 2 | 6 | British | Italy | Male | 24 | 1 |
| 3 | 4 | British | Italy | Male | 22 | 1 |
| 4 | 7 | British | Austria | Male | 29 | 2 |
| 5 | 8 | British | Austria | Male | 25 | 2 |
| 6 | 8 | British | Austria | Male | 25 | 2 |
| 7 | 20 | British | Austria | Male | 38 | 2 |

*Data Collection*

Semi-structured interviews were recorded and transcribed, prior to undergoing reflexive thematic analysis. Semi-structured interviews provided a framework which guided discussion through the interview schedule which ensured relevancy of content, while still allowing participants the freedom to engage in fluid discussion rather than adhering to a strict structured format (Adeoye-Olatunde & Olenik, 2021). The ability to conduct interviews remotely removed any logistical issues that may have occurred in an observation- or intervention-based study.

Pilot interviews were conducted prior to data collection, during which found statement prompts were more effective in generating discussion than specific questions and the interview schedule was subsequently amended to include both styles. Data collection interviews were conducted via Microsoft Teams and each interview was recorded and subsequently transcribed. The interviews were each 1 hour in length, and participants were notified of the beginning of recording, and were assured that the

interview could be paused or ended at any time. The interview schedule began with discussion of coaches' backgrounds and the operational structure of their ski academy and then moved on to more focused discussion about the coaches' experiences of the coach-athlete relationships and transitions in their academy. These questions and the follow-up statement prompts were designed to give the participant space to reflect on their professional practice, and to provide flexibility within the interview for the participant to lead discussion.

*Data Analysis*

The analytical framework for this project is reflective thematic analysis (RTA), which allows the researcher to identify patterns or codes within the interview data and subsequently examine broader themes in order to identify areas of commonality or divergence between interview responses and develop analysis (Braun & Clarke, 2006; Braun & Clarke, 2022; Braun & Clarke, 2023). This framework allows for a degree of flexibility in the research direction, as analysis is able to organically follow the themes that are identified while remaining aware of researcher subjectivity (Braun & Clarke, 2023). This choice of analytical framework is supported by research examples including a study conducted by Garner and Hill (2017) who applied thematic analysis to a qualitative focus group study conducted with ski coaches on Community of Practice (Garner & Hill, 2017). The thematic analysis in Garner and Hill's (2017) study was used to identify core elements of coaches' practice and validate the research hypothesis, and the application of this technique in the current research will be similar (Garner & Hill, 2017). A crucial element of this analytical framework is the reflexive aspect, as this identifies data points that were highlighted by participants as having high value, as opposed to assigning value by more traditional metrics as in a content analysis (Braun & Clarke, 2013; Braun & Clarke, 2023). This reflexivity in the data analysis process was particularly effective in identifying themes which were not originally included in the scope of inquiry, but which became important to the research findings through the participants' direction. An example of this is the identification of integration into academy and training-to-race as key transitions; sub-themes that emerged as a result of the participants' assignation of value and which would not have been possible without the use of RTA as analytical framework; Table 2 shows a step-by-step breakdown.

**Table 2.** Reflective thematic analysis process

| | **PROCESS OVERVIEW** |
|---|---|
| **STAGE 1** | Review of interview transcripts and recordings and creation of initial thematic maps to capture raw codes and identify recurrent themes in each individual interview (Process repeated for each interview) |
| **STAGE 2** | Formalisation of identified themes<br>Comparison of themes across individual interviews |
| **STAGE 3** | Identification of themes common across participants |
| **STAGE 4** | Formal identification of overarching themes common across all participant data<br>Identification of high value transitions and sub-themes |
| **STAGE 5** | Situation of identified themes in the context of existing knowledge and literature |

With regards to researcher reflexivity, reflexivity was incorporated into the analysis and research conduct to help mitigate any biases that may have arisen from the lead researcher's longtime involvement in the British ski racing community (Braun & Clarke, 2013). This was exercised in particular relation to the sample population: the coaching staffs of both participating academies were entirely male, meaning that all coaches included in this study were male. As a result of this, there was initial concern that this could constitute a skewed sample, and potentially add to preconceptions within the ski racing community that the sport is male-dominated. However, it has to be acknowledged that this sample population is representative of the alpine racing scene in Britain: a predominantly or entirely male coaching staff is very common. This sample also – unexpectedly – created a more open dynamic between researcher and participants, as several coaches shared that the conversations they had with a female researcher were not conversations that they felt comfortable having with other male colleagues. Thus, both the participants' and researcher's genders become a factor in the data produced, highlighting researcher positionality has to be acknowledged. Overall, while the sample population may constitute a limitation due to its narrow gender pool, the dynamic created by having an all-male sample and a female researcher may in fact present an opportunity to gain insight that would otherwise have been unavailable and thus provide us with valuable data and as noted above, is fairly representative of the professional demographic of British ski racing. This provides an example of the ways in which personal reflexivity was exercised by acknowledging preconceived assumptions and recognising potential limitations in sampling, but also in understanding the ways in which the researcher's position can contribute to the production of data.

## Results & Discussion

Table 3 provides an overview of the thematic analysis. Common themes that recurred across the interview data formed emergent sub-themes, indicative of the 4 transitions found to be most significant. Beyond the transitions initially intended for research, there were 2 new transitions identified: the athlete's initial integration into an academy; and the lateral transition between training and race settings. The sub-themes were then identified as higher order themes of either lateral or longitudinal transition types.

**Table 3.** Thematic Analysis Map

| THEMES | SUB-THEMES | HIGHER ORDER THEMES |
|---|---|---|
| Commitment & intensity of TDE | Integration into academy | Longitudinal Transitions |
| Team culture & athlete integration | | |
| Coaches' role in facilitating preliminary transition | | |
| U16 to FIS | Age & stage | |
| Relationship dynamics across age groups & continuity | | |
| Process over performance: holistic athlete development | | |
| Balancing different roles | Training to home | Lateral Transitions |
| Coaches' involvement in pastoral care | | |
| Coaches' role in athlete discipline | | |
| Minimal separation between training & home environs | | |
| Identity foreclosure | Training to race | |
| Adaptability & communication | | |
| Increase in athlete stress | | |
| Calming vs. aggressive pre-race dialogues | | |
| Impact of gender | | |
| Parental pressure & coaches' role as buffer | | |

The results pertaining to longitudinal transitions were found to broadly align with established evidence of the evolution of the coach-athlete relationship over a long-term training partnership. The most significant results of this project were found in the context of lateral transitions. Throughout the Discussion section of this paper, there are quotes from coaches in interview which support these

findings, underline the significance of the themes identified, and provide insight into the implications of these themes for practitioners. The following discussion will begin by exploring in more detail the findings related to longitudinal transitions and will then focus in greater detail on the lateral transitions.

*Integration into Academy*

Athletes' initial integration into academies was found to be the most significant longitudinal transition, and within this, athletes' assimilation into the home environment of the academy was found to be more important for the success of this transition than their adjustment to the intensity of the training load. The research found that coaches played an influential role in facilitating this transition and particularly in building relationships with athletes to ensure their comfort in living away from parents. The integration phase into a ski academy means a change from 90-minute training sessions and returning home to their parents, to living in the European base of their ski academy for 2-3 week blocks and training 5-6 days per week. The full-time training programme for the 2022/23 season for Academy 1 was 16-18 weeks, while the full-time programme for Academy 2 was 25-30 weeks. While not one of the original focuses of this study, the research found that this transition is one of the most significant for athletes, and furthermore, the success of the athlete's integration is crucially influenced by the coach-athlete relationship. This transition out to academy falls in what Bloom refers to as the "middle years" of talent development, a stage at which athletes are typically becoming more committed to their sport and correspondingly a point at which coaches become more significant figures in athletes' psychosocial spheres (Bloom, 1985; Wylleman & Reints, 2010). The role of the coach in supporting athletes' adjustment to their new environment aligns with previous research which has placed the coach-athlete relationship at the centre of successful athlete transition through talent development stages (Wylleman & Reints, 2010; Jowett & Poczwardowski, 2007).

Beyond the physical adjustment to the increased training load of a full-time academy, coaches highlighted the intensity of the emotional adjustment to academy life for new athletes:

> "they're going to miss mum and dad [...] you're skiing every day and skiing with a purpose. [...] the intensity can be really tough also, like, they're in a very close proximity to people they usually deal with for like 1 or 2 hours but then they're living with other kids as well." (**Participant 6**)

Adjustment to the home environment in the academy was found to be more critical to athlete's success than adjustment to training load, and it was also clear that the coach-athlete relationship was significant in supporting this:

> "I also play quite a big role in them just feeling comfortable being away from their parents, living in Austria with the group of teenagers." (**Participant 6**)

These results begin to indicate the role that coaches play in the home environment as well as the training environment and the coaches' awareness of their influence, and furthermore, demonstrate the importance of the long-term commitment to developing the coach-athlete relationship to support athletes' wellbeing and overall success in academy.

In light of this, the current research setting can best be compared to boarding schools – a comparison that was in fact made by a participating coach. In a boarding school setting, teachers play a significant role in both the socialisation of their students, and in the assimilation of those students into the internal culture of the setting; this mirrors the findings of the present study, as coaches noted their influence in making athletes comfortable in their new living environment and also in modelling acceptable behaviours within the home environment (James, 2023). The coaches' position here in modelling behaviour and constructing the academy culture corresponds to the psychosocial domain identified in Wylleman's lifespan model as young athletes' dispositional development is influenced by their coaches and their sports development settings (Debois et al., 2015; Wylleman et al., 2004). Furthermore, it has been found in school settings that the success of students' initial integration into the social environment and their understanding of teacher expectations is associated to their subsequent performance. Subsequently, this provides a basis for the findings of the current research study, in which it has been found that athletes' social integration is central to their success and continued progression within the academy, and which again relates to the lifespan model in the extent to which the academy setting influences athletes' development (Debois et al., 2015; Wylleman et al., 2004).

*Age & Stage*

One of the original purposes of this study was to examine how the coach-athlete relationship impacts and is impacted by the athlete's progression through age and competitive stages in one academy setting. The longitudinal development of the coach-athlete relationships as athletes progress through age and competitive stage was found to align with established norms of coach-athlete relationship

progression, as has been found in previous studies across sports with the gradual evolution of the relationship from that of teacher/student to a more equal partnership of mentor/mentee as athletes age (Philippe et al., 2011; Collins & MacNamara, 2018).

**Table 4.** Age & Stage Relationship Breakdown

| AGE BAND | TRAINING FOCUS | RELATIONSHIP DYNAMIC |
|---|---|---|
| U10/U12 | Learning through play | Playful |
| | More instruction | Instructional/authoritative |
| | Developing confidence | Flexible |
| U14 | Structured | More focused in training, less instructional |
| | Technical development | More dialogue between coach & athlete about technical skills & rationale, athlete questioning more |
| U16 | Adaptability | More independent, given more freedom (particularly in home life) |
| | Competitive focus | Managing expectations for FIS transition |
| | Increased commitment | More dialogue between coach & athlete as athlete's technical knowledge is established |
| U18/U21 | Self-motivation | Trust in coach's knowledge & decision-making, less questioning |
| | Less structured | More of a dyadic relationship than teacher/student as in younger age bands |

Table 4 above offers a concise overview of the development of the coach-athlete relationship as athletes age progresses. These findings are aligned to much of the existing literature on the development of coach-athlete relationships, and demonstrate the trust and continual adaptation to athletes' needs necessary to building these relationships over time (Davis & Jowett, 2014; Jowett, 2017). This was highlighted by **Participant 7** who stated that:

> "coaches try and reduce the intensity of that [age and stage] transition as much as possible."

By maintaining the same peer group, coaching team and training environment as far as feasible, noted key components of strong communication and trusting coach-athlete relationships as essential to facilitating successful age and stage progressions (Davis & Jowett, 2014; Jowett, 2017). In the later stages of athletes' time in academy, there was again a crux moment where coaches had to adapt to

evolving athlete needs. This was coaches' awareness of and specific attempts to facilitate traits of independence in older athletes:

> "…even athletes on the FIS team when they're 20/21 [years old], they'd say that they were also treated like [kids]." (**Participant 5**)

In the example given by **Participant 5**, the older athletes "fought back a little bit" and eventually Academy 2 went on to institute a senior athlete apartment separate from the main residence where older or "university age" athletes could gain more independence. This again demonstrates the adaptability of coaches in such intensive settings and their role in taking developmental decisions (such as living independently for the first time) that would normally fall under the purview of parents and again emphasises coaches' awareness of the changing needs of athletes as they age and progress.

*Training to Home*

The lateral transition between the on-snow training environment and the home setting in academy was found to be one of the most significant, and returned three major findings: the extent of coaches' pastoral responsibility in the home environment; the lack of separation between coaches and athletes in the residential academy structure; and the role of coaches in mitigating identity foreclosure in an intensive talent development environment. These are some of the most important findings from this study overall. While there has been consideration in previous literature of the formative nature of coaches' influence on young athletes' development, there has been no research conducted on a talent development setting of this type in which coaches and athletes live together, and in which the coaches reported taking on primary caring roles for their athletes. Roux and colleagues (2022) found that coaches often take on more formative roles in athletes' personal development as a result of participating in dedicated sports academies, an assertion that is upheld by the present study, but their research does not extend to how this influence may be increased by coaches and athletes having no separation at the end of the training day (Roux et al., 2022).

The importance of context to athletes' development and to the relationships that influence this development is proven by Bronfenbrenner's bioecological model, in which the environment and subsequent relationships are considered as interactive components (Domingues & Goncalves, 2014). This interaction is demonstrated in the findings of this study, as the specifics of the environment created the need for coaches to take on more pastoral responsibility and this, in turn, was found to impact the closeness of the coach-athlete relationships within the setting. This also further compounds

the significance of the coaches' position in the psychosocial development domain, thus overlapping the bioecological with the lifespan model. 6 of 7 coaches included in the study reported being aware of their level of influence on athletes' personal development, and felt this was increased by the lack of separation that comes with the integrated residential setting:

> "It's a little bit scary to think about how much of an influence you can have on them, you know, there's that saying that somebody's sport coach, whatever sport it is, whatever they're doing, they can have more influence on that child's life than any other adult other than their parents in their entire lifetime." (**Participant 2**)

Coaches' reports of this awareness further highlighted the closeness of the coach-athlete relationship and the level of care required by such an intensive setting, components that have long been understood as integral to the success and efficacy of the relationship and to athletes' long-term development and performance (Davis & Jowett, 2014; Hampson & Jowett, 2014; Taylor, Ashford, & Collins, 2022). The extent of this involvement relates to research conducted by Taylor and colleagues who discussed the capacity of coaches to "care for and about athletes", characterising this as coaches' engrossment in the athletes' lives and needs, high levels of empathy towards athletes, and "motivational displacement" in which coaches prioritise the needs of athletes to the potential detriment of the coaches' own wellbeing (Taylor et al., 2022, p. 91). These traits are clearly exhibited in the findings in in the lateral transition from training to home, wherein athletes' needs come before those of the coach as a matter of routine: "all we do every day is for them" (**Participant 6**). What all of this demonstrates is the significance of the lateral transitions between training and home environments to the coach-athlete relationship, and the way in which this transition changes the dynamic of the coach-athlete relationship from that of a traditional sports coach to a much more involved relationship based on care and the coaches' desire to "look after" athletes, in turn creating a much more intensive professional role for coaches (Taylor et al., 2022).

Table 5 provides an overview of what coaches reported as the average "inlier" or residential training day in the academy programme: this demonstrates again the intensive nature of the academy structure, underlines the crossover in training and home environments, and emphasises the prioritisation of athletes' needs. What is also made clear through these findings is a gap in the existing research: specifically, the lack of consideration of how the transition to a pastoral setting can impact the coach-athlete relationship as a whole – a transition which, as we can see from this study's evidence, plays an incredibly significant part in the coach-athlete relationship and the coaches' own

wellbeing. Thus, understanding how particularly the lateral transitions in academy settings impact coach-athlete relationships can provide insight not only into the specifics of that relational dynamic, but can also reveal where greater support and education for coaches can help to support them in preparing for and developing in residential academy work.

**Table 5.** Table detailing average "inlier" training day in academy

| ACADEMY 1 DAY | | ACADEMY 2 DAY | |
|---|---|---|---|
| 6:40 | Wake-up | 6:30 | Wake-up |
| 7:00 | Breakfast | 6:40-7:00 | Activation exercises |
| 7:45 | Commute to mountain | 7:00-7:45 | Breakfast |
| 8:00-12:30 | Ski training | 8:00 | Commute to mountain |
| 12:45 | Lunch | 9:00-13:00 | Ski training |
| 14:00-17:00 | School/coaches begin ski prep | 13:00-14:30 | Lunch & video analysis |
| 17:15-18:50 | Fitness session, video analysis, ski prep | 15:00-18:00 | School |
| 19:00 | Dinner | 18:30 | Dinner |
| 20:00-21:00 | Downtime | 19:30-21:00 | Downtime, gym session/alternate sports |
| 21:00 | Athlete bedtime | 21:00 | Athlete bedtime |
| 22:00-23:00 | Coaches finish ski prep, coaches' bedtime | 22:00-23:00 | Coaches' bedtime |

The data collected from this project also indicated that there is a disconnection between the way that British ski academies' pastoral care provision is supposed to operate and how it actually does operate: this is seen in the fact that while both academies have dedicated pastoral staff ("house parents") whose role is to take on the pastoral caring responsibilities in the academy home, coaches from both settings reported still taking on domestic responsibilities:

> "we're almost like dads there [...] you need to realise that you're going to be in charge of dealing with not just the coaching but, you know, making sure they're eating, sleeping, resting, doing school, showering." (**Participant 5**)

It is clear here the scale of coaches' non-sporting responsibility and the high level of emotional involvement that coaches have with their athletes. The coaches' position in shaping athletes'

behaviour and overall development again corresponds to Bronfenbrenner's bioecological model in the influence of relationships and environment on athletes' dispositional development (Bronfenbrenner & Morris, 2006). Again, previous applications of Bronfenbrenner's model in the sports context fall short of the level of involvement seen in the present research context where coaches' influence on athletes' dispositional and behavioural development is more significant and other significant relationships (i.e., parents, teachers, or non-sporting peers) have a more limited impact by virtue of athletes' living in academy.

Yet despite of the lack of separation between coaches and athletes, and coaches' often intense pastoral responsibility, all coaches in this study stated that they would prefer to live with athletes than live apart, and all view the integrated living environment positively. Coaches emphasised the closeness of the setting and correspondingly, of the relationships, as a positive outcome from the integrated environment and felt that they were better placed to "look after" athletes when they were living together (Taylor et al., 2022):

> "I quite like it because I feel like I can get more responsibility. I can look after them. I can make sure they're doing the things they need to do and also manage, like I said, that balance, balanced lifestyle a bit better. And it's helpful for them as well that they can come and just talk to me if they have a problem or, you know, my door's always open and obviously I'm always doing something for them or available to them. So, in some ways I find it actually better to live with them than live away." (**Participant 6**)

This again emphasises the impact of the lateral transition between training and home on the coach-athlete bond and demonstrates how integral this transition is to the development of closeness and provision of care in the coach-athlete relationship in ski academies (Hampson & Jowett, 2014; Taylor et al., 2022). However, coaches across both academies shared that they did not feel prepared for the pastoral element of the role before moving out to academy, which heightened the level of pressure that came with such responsibility. This was made most clear with regards to discipline in the academy home. Coaches from both academies noted that the disciplining of athletes often fell to coaches rather than house parents:

> "There was a lot of difficult, challenging behaviour issues that we had to deal with, which would normally be more like a thing that parents would eventually have to deal with,

> with teenagers and stuff like that, […] which was really, really tough as well. And I don't think we were massively well equipped for that." (**Participant 5**)

The fact that discipline is often administered by coaches reinforces the coach-athlete relationship as the most significant relationship within the setting despite the presence of house parents, and underlines the ways in which the lateral transition between training and home changes the dynamic of the coach-athlete relationship:

> "the teachers or the house parents weren't as like, I guess as strict as us, or the kids didn't respond as well to them. So, then we'd be in charge of all that discipline stuff as well, which I hated. But I had to do it because it was just part of the role." (**Participant 5**)

What these findings demonstrate is the impact of the lateral transition between the training and home settings on the coach-athlete relationship, as domestic disciplinary responsibility is integrated into the coaching role in a manner that would not occur without the residential component to the academies. A key aspect to note within this is the coaches' acknowledgement that they did not feel "equipped" for this responsibility, a comment which carries implications for both academy practice and coaching education provision (**Participant 5**). Related to this, coaches across both academies reported being "responsible for the culture and the behaviours and you know, setting examples of what's acceptable, what's not" (**Participant 6**). This is another element of developmental responsibility that goes beyond sports instruction and again emphasises the level of pastoral responsibility embedded in the coaches' role in the residential academy settings. Overall, this indicates a lack of education or preparation on the pastoral role during the coaching qualification process. While all coaches noted the normalisation of such structures in British ski racing and reflected on their own positive experiences as athletes in similar environments, this did not diminish coaches' perception of the intensity of the coaching role:

> "It was tough for us. It was definitely tough for the kids as well. The kids, you know, they don't have much space. They're with coaches who do become more like… It ends up becoming like a family. [...] You're never off the clock as well. So when, you know, the kids go to bed, you have to be quiet. So, everything revolves around the kids." (**Participant 5**)

This evidence in particular highlights the duality of these settings: while coaches feel positively about the level of responsibility and care they can develop in the residential academies, this comes alongside the acknowledgement of the impact such an intensive setting has both on coaches' own wellbeing and on the fundamental nature of their relationships with their athletes.

The research also found that coaches' roles in mitigating identity foreclosure in athletes was heightened by the overlap in training and home environments. The significance of the coaches' role corresponds to previous research which highlighted a number of factors that increase the likelihood for young athletes to experience identity foreclosure: for example, the pressures of peers, parents, and the intense environment of ski academies themselves, all of which were also noted by coaches in this study as factors contributing to the risk of foreclosure (Petitpas & France, 2010; Fawver et al., 2020). Coaches across both academies noted their role in ensuring that athletes communicated with friends and family outside of the academy, and actively encouraged their interests in other sports and alternate activities to ensure that athletes continued to develop interests and social networks beyond just ski racing:

> "I also find it's important they have time to call friends back home, call parents. Just chill out and do things they want like normal teenagers, like here, they can sometimes be almost like a little bit robotic" (Participant 6). This finding particularly emphasises the closeness in the coach-athlete relationship, as this is the element that allows coaches to recognise this "robotic" tendency in athletes and then encourage or facilitate changes in behaviour (**Participant 6**)

Again, this role was intensified by the lateral training-to-home transition as coaches would not be responsible for monitoring these types of communications if athletes lived with their parents: thus, it is clear that coaches take on a more formative position for athletes' dispositional development as a result of this transition. These findings connect back to Wylleman's lifespan and Bronfenbrenner's bioecological models in the coaches' awareness of athletes' holistic development and the consideration of non-sporting factors, or "proximal processes" in Bronfenbrenner's model, and their potential impact on athletes' performance and personal development (Wylleman & Reints, 2010; Bronfenbrenner & Morris, 2006).

Due to the lack of previous research into academies in which coaches and athletes live together and the rarity of such a structure in sport more broadly, it is understandable that coaching education does

not encompass the domestic roles of coaches, but as this study has demonstrated, this aspect of the coaching role is significant to both coaches and athletes and is widely – albeit informally – acknowledged as common in the British ski racing community, and therefore could be more specifically addressed in coaching education in the UK. This would help to mitigate the lack of preparedness and sense of overwhelm described above, thereby better preparing and protecting coaches from potential burnout.

*Training to Race*

The final point of discussion is the lateral training-to-race transition. In this sub-theme, there were two key elements identified that contribute to the significance of this transition and its impact on the coach-athlete relationship: these were the coaches' role as buffer between athletes and parents, and the impact of gender. Leading on from the discussion above of coaches' awareness of "proximal processes", a prime example of this was identified in the training-to-race transition, in which coaches reported acting as "buffers" (Participant 1) between parents and athletes. The crux of this "buffer" role comes at the transition to race settings, as coaches reported the pressure from parents heightened during race periods in comparison to the athletes' day-to-day and thus prompted intervention on the coaches' part to shield the athlete(s):

> "I just phone parents in the winter to tell them to just get out, to be honest. There're some guys, you know, they're getting their kids and saying 'oh, you know, you only came 4th in this run and this person's beating you, this person is beating you here' but they have no idea the context of training or anything like that right. I just pick up the phone and just say, 'look, give them a break' which doesn't always go down well but tough." (**Participant 1**)

The pressures often exerted by parents in competitive youth sport are well documented and known to be potentially detrimental to athletes' performance and wellbeing, and the role of the coach, as seen here stepping in to protect the athlete from that pressure, further exemplifies the closeness of the coach-athlete relationship and the more influential position of the coach by virtue of living with the athletes (Smoll et al., 2011). This is a prime example of the ways in which the varying environmental transitions in the ski academy setting interact with one another and with the coach-athlete relationship to prompt behaviours that would not otherwise occur: in this instance, the lateral training-to-race transition interacting with the coach-athlete relationship as it occurs in the residential setting demonstrates how the closeness gained through the residential environment informs everything else.

Further to this, there was another key finding specific to the training-to-race transition: the impact of gender. The data from Academy 2 showed that the coach-athlete relationships between female athletes and the all-male coaching team were strong in the training environment and were consolidated over time, with coaches in interview highlighting that athletes were comfortable enough to discuss personal issues like periods with their male coaches. However, in the race setting, coaches reported that female athletes showed high levels of pre-race anxiety:

> "especially girls, I think, put a lot more pressure on themselves than the boys. [...] I really noticed that especially with girls, they would struggle to convert the training performances to race performances. With the boys, that was slightly easier. I don't know if that's something to do with the fact that we have an all-male coaching line-up." (**Participant 1**)

This data corresponds to previous research which shows that female athletes typically experience higher levels of pre-performance stress than their male teammates, and that this is particularly apparent in individual sports (Gligor et al., 2021; Correia & Rosado, 2019). In response to their observations, the coaches in Academy 2 changed their communication style with female athletes when in the race environment:

> "To put it bluntly, I'll probably be a lot nicer to girls that I will be to boys because that seems to work better." (**Participant 2**)

However, as this did not generate significant improvement, the female house parent was added to the race support team for the female athletes. The house parent acted as a purely supportive figure with no technical coaching input. As was stated by one of the coaches, the decision to put the female house parent in the race setting was in an effort to:

> "just try and make [the girls] feel comfortable, find out how they're working, how they're not working, all that kind of stuff. And because there are things that a 13-year-old girl is going to tell a female member of staff but not tell a male member of staff." (**Participant 1**).

Following this augmentation, coaches observed an immediate improvement in the girls' race performances:

> "to have [the house mum] on the hill, all of a sudden, the girls just went from like zero to hero. There were so many changes [in performance] and there was no coaching input at all." (**Participant 1**)

This finding demonstrated that despite the closeness of the coach-athlete relationships in the training environment, the race transition changed the dynamic of that relationship and therefore the relationship had to be adapted with the addition of the female house parent.

It has been found in previous research that the communication and support needs of female athletes in coach-athlete relationships differ from those of male athletes, however the complexity in the present study's finding is that those needs only changed when the transition from training to race occurred (Weiss & Kipp, 2018; de Haan & Norman, 2020). What this does demonstrate however is the coaches' ability to recognise limitations in the male-coach-female-athlete relationship and adjust in order to meet the needs of the athletes (Taylor et al., 2022; de Haan & Norman, 2020). This example also further emphasises the impact of the environment on the dynamic of coach-athlete relationship, a finding which has been evidenced in both of the lateral transitions identified by this study. Finally, it should be noted that as a result of coaches' observations, the coaching line-up for Academy 2 was changed for the following season to include female coaching staff.

*Limitations*

There are certain limitations in the present study: the sample population was comprised of all male coaches, which restricts the level of insight regarding female coaches' experiences of coach-athlete relationships and transitions, and the sample population consisted of only two academies. Due to these restrictions in the sample population, it may be worth conducting further study in which female coaches are included and in which a larger sample population is used. This research was also conducted via interview remotely, limiting the ability of the researcher to observe the coach-athlete relationships in their settings and so again, this subject may be worthy of further investigation through an observation-based study.

*Conclusions & Implications for Practice*

This study has focused on a type of talent development setting which has not previously been studied, and as a result of this, the research has added novel data to the existing body of knowledge on the coach-athlete relationship. The aim of this study was to investigate the impact of transitions on coach-athlete relationships in the context of British ski racing academies, and the research has concluded that transitions carry significant impacts and can enact change on the very nature of the coach-athlete relationship. The research identified more transitions than were originally intended for study, finding that the initial integration into academy and the lateral transition from training to race environment were particularly significant. The examination of the interaction between transition and coach-athlete relationship corresponded to established theories and demonstrated the importance of viewing the coaching role and the coach-athlete relationship holistically and with consideration for the role of the development environment. The most important findings of this research were the significance of lateral transitions to the coach-athlete relationship, and the importance of successful initial integration of athletes into the residential academy environment. In particular, the discussion of lateral transitions provides novel data on the extent of coaches' pastoral roles in residential academy settings and the impact that integrated training and living environments has on coach-athlete relationships. The emergence of gender as it relates to the training-to-race transition and the impact of that interaction on coach-athlete relationships also holds implications for coaching provision, as this finding indicates the need for more female coaches or members of staff in these intensive environments.

Finally, there are significant implications for coaching education in the findings regarding coaches' pastoral roles: the scale of coaches' involvement in pastoral care has been demonstrated clearly by this study, as has the fact that some coaches did not feel prepared for this part of their role. In order to better prepare coaches and thereby provide better care to athletes, the pastoral side of academy coaching should be addressed specifically in coaching education.

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## Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to data restrictions, namely survey responses containing information that could compromise the anonymity and privacy of research participants.

## Conflicts of Interest

There are no relevant financial or non-financial competing interests to report.

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## Research Article

# The effect of altitude on decision making in male rugby union players

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Running Title: hypoxia and cognitive function

## Abstract

The body is typically forced to undergo several physiological adaptations when exposed to hypoxia, which can impact physical and cognitive performance. The purpose of this investigation was to study the effects of altitude on cognitive function, specifically decision-making, in male athletes. Seven male rugby union players, at senior club level or above, performed a 15-minute cycling protocol (70-80% HRmax, with 3 × 6-s maximal sprints performed at 5, 10, and 15 min) in normoxia (FIO2 = 0.21%) and hypoxia (FIO2 = 0.15%) in a randomised order. Throughout both trials, a Stroop test was conducted immediately after each sprint to assess decision-making ability. Additionally, heart rate (HR) and rating of perceived exertion (RPE), along with average and peak power output were recorded. Stroop test time (13.3 ± 1.6 vs. 11.8 ± 1.6 s) and SPO2 (87 ± 2 vs. 97 ± 1%) were impaired in hypoxia compared to normoxia (P = 0.029 and P < 0.01 respectively). All other outcome measures showed no difference between trials. These data confirm that player decision making is negatively affected by altitude, likely due to reduced cerebral oxygenation driving the cognitive impairment. Our findings infer that while rugby union players may be capable of maintaining physiological stability over short durations at altitude, their cognitive ability may be inhibited, resulting in potentially handicapped decision-making during high pressure game situations.

**Keywords:** cognition, hypoxia, normoxia, performance.

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# Introduction

Hypoxia is widely defined as a severe reduction in oxygen within blood vessels and tissues, limiting physiological ability to maintain homeostasis (Span and Bussink, 2015). An increase in altitude elicits a drop in barometric pressure, subsequently reducing the partial pressure of ambient oxygen (PaO2). Consequently, individuals at high altitude experience a constrained oxygen supply, most notable when exercising (Su et al., 2024), presenting the well-researched challenge of adapting to this altered environment. The body is typically forced to undergo several physiological adaptations when exposed to hypoxia, which can impact physical and cognitive performance (Bailey et al., 2017).

Oxygen deficiency experienced in a hypoxic environment has been shown to elicit reductions in cerebral oxygenation (Komiyama et al., 2015, Morrison et al., 2019) and as a result, cognition. Cerebral oxygenation is reliant on pulmonary and ventilatory systems (Koike et al., 2004), which are required to adequately meet increased neuronal metabolism in the brain (Secher et al., 2008). Hypoxia encourages the excitation of specific neurons (typically located in the caudal hypothalamus and rostral ventrolateral medulla), which subsequently increase respiratory activity, heart rate, and blood pressure to account for the decline in physiological function (Goodall et al., 2014a). Consequently, reduced levels of oxygen mean the demand for this supply to the brain is intensified often beyond the capabilities of the body, leading to cerebral oxygenation reduction and overall cognitive impairment (Wang et al., 2022). Cognitive function has been widely researched from a mountaineering perspective with a focus on the effects of acute hypobaric hypoxia, and some altitude-related diseases that may occur as a result (Richalet et al., 2024). McMorris et al. (2019), reported that the level of haemoglobin saturated with oxygen (SPO2) was the main predictor for the reduction in cognitive ability. A wide range of assessments have been employed previously to evaluate cognitive performance such as decision making, reaction time, and task efficacy. Langenecker et al. (2007) identify the Go/No-Go Test as an effective method of identifying an individual's inhibitory control and reaction time by forcing a response to a stimulus. Similarly, the Trail Making Test (Reitan and Tarshes, 1959) assesses processing speed and cognitive flexibility, with participants aiming to connect sequences of number or words as quickly as possible. More commonly used are simple and choice reaction time tests, often employed in sport to assess concussion severity or recovery status (Tommerdahl et al., 2020), or in a more clinical setting to assess diseases such as multiple sclerosis (Cabib et al., 2015).

While these methods of assessment are all justifiable in sport-specific studies, they do not critically assess or specifically target decision-making ability. The Stroop Colour and Word Test (Stroop, 1935),

however, remains arguably the most effective method for this specific cognitive investigation as it attempts to inhibit cognitive interference to complete an automated task (Scarpina and Tagini, 2017). By doing this, it measures selective attentional focus and cognitive flexibility, which are all key elements in high-pressure sporting decisions (Keeler et al., 2014). Furthermore, the Stroop test has been extensively used to detect changes in cognitive performance within sporting environments, with previous work using it in fatigue, stress, and environmental contexts (Post et al., 2023), providing credibility for use within rugby.

The effect of acute hypoxia on cognitive function has also been evidenced by increased error rates, where such a slowed performance is described as a cognitive symptom revealing a potential subconscious strategy to minimise mistakes (Hornbein, 2001). Despite its relevance, this work focuses on the ascent of Mount Everest, and while it looks at 'moderate hypoxia', typically 2,000-4,500 m (the lower bound similar to the interests of the current study), it does not directly compare to the effects hypoxia may have on rugby performance, in particular player decision making. It does, however, conclude that these levels of altitude can impair brain function when in a state of hypoxia, fuelling the present research question that assesses the extent to which this happens in a sport-specific scenario. León-Carrion et al. (2008) investigated the effect of reduced cerebral oxygenation and Stroop test performance, concluding that impaired performance could be due to an insufficient oxygen supply. However, such evidence relating to rugby union players is limited.

Regarding exercise, acute hypoxia exposure is seen to have effects on multiple performance measures, with the general trend that performance is hindered due to the combination of decreased supply of oxygen and increased fatigue (Amann et al., 2007, Goodall et al., 2012, Goodall et al., 2010, Romer et al., 2007) which is reversible with acclimatisation (Amann et al., 2013, Goodall et al., 2014b). Metrics such as power output, maximal oxygen consumption, and peak speed are all negatively affected by hypoxia (Scott et al., 2017, Simpson et al., 2015). In a rugby union setting, this places increased strain on the demands of players who are aiming to perform at optimal physical and mental levels. This has become an increasingly relevant factor in the UK since the introduction of South African teams in the United Rugby Championship (URC) since 2017, meaning Irish, Welsh, and Scottish teams having to travel away to moderate altitude (1,800 m, Ellis Park, Johannesburg). The high intensity nature of rugby union suggests that the working muscles demand a large supply of oxygen, particularly when the body is using aerobic processes to provide energy (Duthie et al., 2003). Subsequently, a high demand of oxygen in the working muscles would likely be matched by a high neural demand for cognitive processes (Keeler et al., 2024), leading to the assumption that performance in hypoxia would be

impaired. Importantly, tactical awareness is widely regarded as a crucial attribute in rugby union (Parrant and Martin, 2010), and a combination of this along with optimal execution of technical skills (e.g., tackling & kicking), provide greater overall team success (Till et al., 2017). As a result, cognitive processing speed and situational awareness are highlighted as the key drivers of decision making (Richards et al., 2016), particularly in open-play settings where approximately half of an 80-minute game is said to be played (George et al., 2015). Finally, the constantly changing game-specific circumstances can be vital for a team's strategy and overall outcome (Ashford et al., 2021), which environmental changes have the capacity to influence.

Accordingly, the purpose of this study was to assess whether cognitive function in rugby players was impacted by exercise in hypoxia. It was hypothesised that altitude would negatively affect player decision making and physiological performance.

# Methods

*Participants*

Seven healthy male rugby union players (Mean ± SD age, 21.4 ± 0.53 years; stature, 184.6 ± 4.3 cm; body mass, 96 ± 13 kg) were recruited from the Northumbria University Men's Rugby Union team. Prior to any experimental procedures, participants provided written informed consent and confirmed their eligibility via the inclusion/exclusion criteria, meaning they were fit and free from injury with no known adverse reaction to altitude, regularly exercising, with previous competitive playing experience of at least 2 years. Participants were instructed to avoid vigorous exercise and adhere to a non-alcoholic, consistent diet, for 24 hours prior to experimental visits. All research activities were approved by the local institutional ethics committee and conformed to the latest revision of the Declaration of Helsinki.

*Experimental Design*

The study was a repeated measures design, with participants completing an exercise protocol in two different conditions (normoxia, fraction of inspired oxygen [FIO2] = 0.21 vs. hypoxia, FIO2 = 0.15) in an environmental chamber (TIS Service Hampshire, UK). Humidity and ambient temperature remained constant across experimental visits at 50% and 17°C, respectively. The outcome measures were peak and average power (W), heart rate (HR), rating of perceived exertion (RPE; Borg, 1982), and SpO2. Participants completed three sessions (familiarisation, hypoxic, and normoxia) with the order of experimental visits randomised. Participants were blinded to the environmental condition, limiting the pre-meditation of condition on performance and improving overall validity. The experimental trials were repeated with a minimum of one-weeks rest in between to mitigate fatigue effects and limit learning of the cognitive task used to assess decision making.

*Procedures*

*Familiarisation*

During the familiarisation, participants were thoroughly habituated with the methods used to understand the physiological and psychological demands of the trial. This involved completion of a 10 minute cycle on a stationary ergometer (Watt Bike, Nottingham, UK), whereby load was gradually increased to elicit a steady state HR of 70-80% maximum (calculated as 220 minus participant age; Mayo Clinic) along with the performance of a 6 s maximal sprint. Participants were also introduced to the Stroop test (MacLeod, 1991), selected to assess cognitive function. This involved presenting a sheet

of A4 paper full of words written in different colours, to the colour they spelt out to participants. The test consisted of naming the colour of the word, rather than the word that was written.

*Experimental Trials*

The sessions began in the environmental chamber with a 5-minute, self-paced warm up, prior to completing a 15 minute constant load bout of cycling at an intensity that elicited (70-80% HRMAX). The intensity was set to whichever Watt Bike gear elicited the required HR, as determined in the familiarisation. Due to the anticipated increase in HR during hypoxia (Goodall et al., 2010), the respective Watt Bike gear was lowered by 1, for the hypoxia trial. During the 15 minute cycle, time was controlled by standardised software (Golden Cheetah) and participants were instructed to maintain a cadence of 75 RPM. At minutes 5, 10, and 15, participants completed a 6 s, maximum intensity sprint, simulating a common duration and intensity of maximum efforts in rugby union (Duthie et al., 2003). A five second countdown was given before each sprint to prepare participants and, to permit a consistent increase in resistance when sprinting, the Watt Bike gear was increased by three for each 6 s period allowing for a greater force to be put through pedals during the maximal efforts; average and peak power values were identified post-testing, using automated software (Golden Cheetah). Upon completion of the 6 s sprint, the Watt Bike gear was returned to the pre-sprint level and participants completed the Stroop test, where the time taken to obtain ten correct answers was recorded; the researcher pointed to random words to be recalled by the participant. A Pulse Oximeter (Biosync B-50DL, Contec Medical Systems, China) was placed on the left index finger to measure SpO2, this parameter along with HR and RPE was measured following each sprint.

*Statistical Analysis*

Data are presented as means ± standard deviation (SD). Data were recorded for each measure after each sprint (5 minutes apart) apart from average power. Data were analysed using SPSS (v29, IBM, Chicago, USA); two-way (2 [condition] × 3 [time]) repeated analyses of variance (ANOVA) were conducted to assess differences in outcome variables with any post-hoc differences assessed using the Tukey comparison. Average power in each condition was assessed using a paired t-test. The level of statistical significance was set at 0.05 and all data are available on request. Figures were drawn using GraphPad (GraphPad software Inc, California, USA).

# Results

Hypoxia had a profound effect on physiological function as demonstrated by lower SpO2 values throughout exercise (87 ± 2 vs. 97 ± 1%, mean difference [MD] = −10%; $F_{1,6} = 197.4$, $P < 0.001$). The condition effect was not accompanied by time ($F_{2,12} = 3.3$, $P = 0.121$) or interaction ($F_{2,12} = 0.3$, $P = 0.784$) effects demonstrating a consistent difference throughout the protocol in each condition (Figure 1A). By design, HR was similar between conditions (167 ± 16 vs. 171 ± 11 bpm; $F_{1,6} = 0.2$, $P = 0.645$) and increased comparably throughout exercise (time, $F_{2,12} = 5.8$, $P = 0.017$; interaction, $F_{2,12} = 0.4$, $P = 0.373$; Figure 1B). Likewise, average power between conditions was similar (155 ± 29 vs. 140 ± 22 W; $P = 0.142$), as too was the peak power elicited in the 6 s sprints (1,059 ± 184 vs. 968 ± 93 W; $F_{1,6} = 2.1$, $P = 0.195$) with a trend for a reduction over time ($F_{2,12} = 3.5$, $P = 0.063$; interaction, $F_{2,12} = 0.9$, $P = 0.437$; Figure 1C).

Perceived exertion was similar during each condition (6.6 ± 1.2 vs. 6.4 ± 1.1; $F_{1,6} = 0.3$, $P = 0.631$) and increased similarly over time ($F_{2,12} = 118$, $P < 0.001$; interaction, $F_{2,12} = 0.4$, $P = 0.561$; Figure 2A). Decision making took longer in hypoxia (13.3 ± 1.6 vs. 11.8 ± 1.6 s, MD = 1.5 s; $F_{1,6} = 8.1$, $P = 0.029$) with pronounced differences at 15 min (13.8 ± 1.7 vs. 11.6 ± 0.7 s, $P = 0.017$). The condition effect was not accompanied by time ($F_{2,12} = 2.4$, $P = 0.137$) or interaction ($F_{2,12} = 0.8$, $P = 0.469$) effects, demonstrating a stable response throughout the protocol in each condition (Figure 2B).

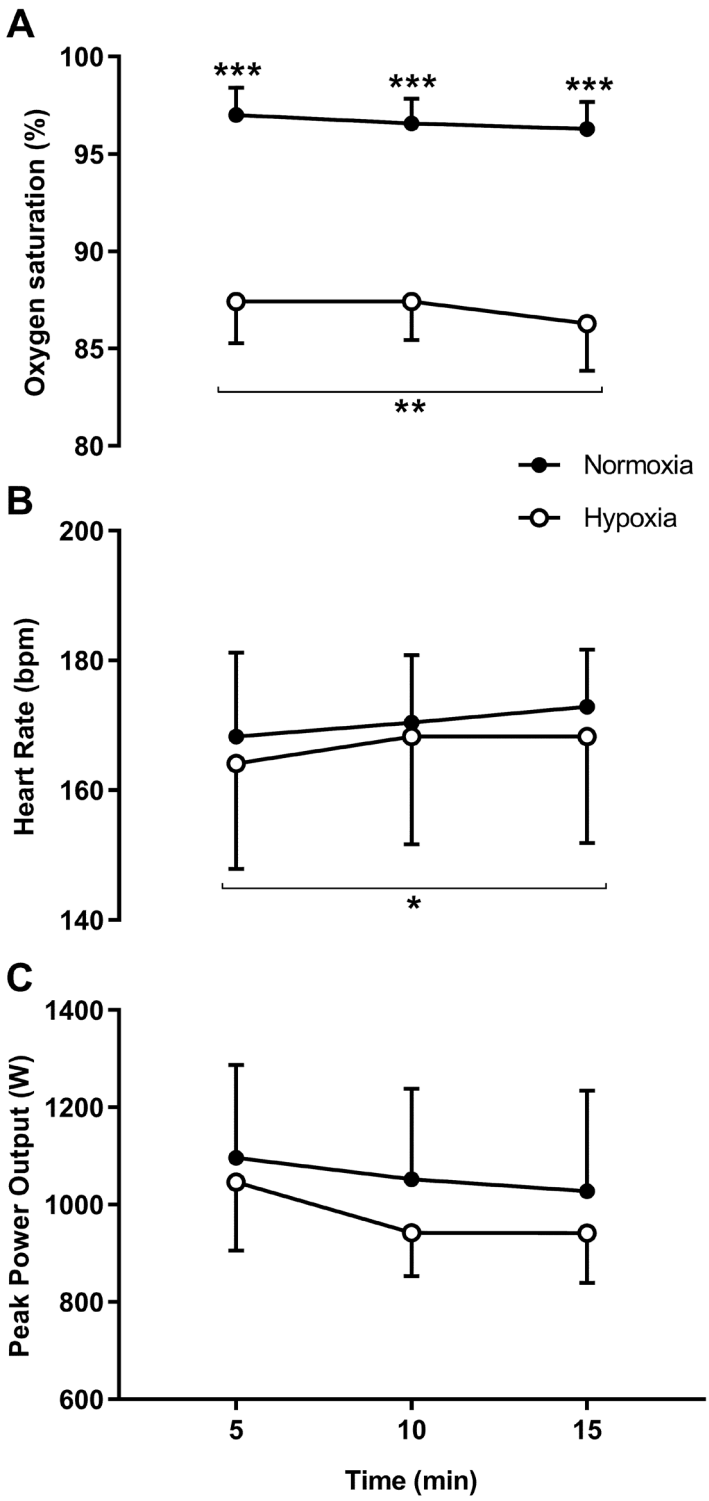


**Figure 1.** Oxygen saturation (A), heart rate (B), and peak power output (C) throughout the 15 min cycling trial performed in normoxia and hypoxia. Data are for 7 participants. * = P < 0.05 time effect; ** = P < 0.05 condition effect; *** P < 0.05 vs. hypoxia at that time point.

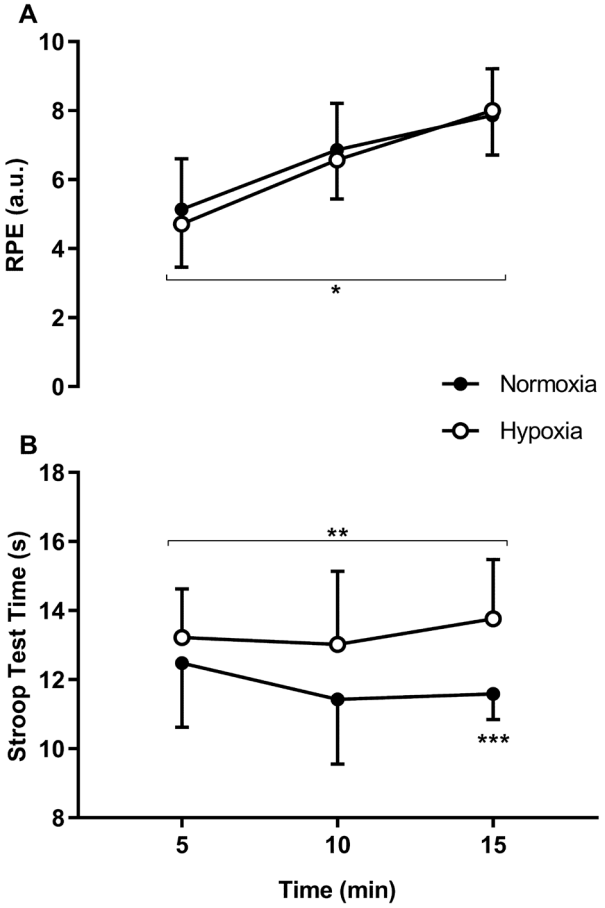


**Figure 2.** Rating of perceived exertion (A) and the time take to record 10 correct Stroop test scores (B) throughout the 15 min cycling trial performed in normoxia and hypoxia. Data are for 7 participants. * = $P < 0.05$ time effect; ** = $P < 0.05$ condition effect; *** $P < 0.05$ vs. hypoxia at that time point.

# Discussion

The purpose of this investigation was to evaluate the effect of altitude on cognitive function among men's rugby union players. The main finding was a reduced cognitive performance in hypoxia, characterised by longer times to complete the Stroop test. The difference in physiological function was stark, with large differences in arterial oxygen saturation, however, no differences were apparent in any other outcome measure (HR, RPE, and PPO). These data confirm that player decision making is negatively affected by altitude, likely due to reduced cerebral oxygenation driving the cognitive impairment.

The decrement in Stroop test performance in hypoxia strongly aligns with previous research suggesting that executive function is impaired by hypoxia, most notably cognitive tasks which require attentional focus and rapid decision making (Keeler et al., 2024). As previously stated, cerebral oxygenation is the most likely cause of the observed decline in cognitive performance, with decreased levels inhibiting prefrontal cortex activity as a result of increased oxygen strain in hypoxia (Bailey et al., 2017). Our study identified that the most notable decrease in Stroop test performance came after the third sprint (15 minutes; Figure 2B), suggesting that fatigue and hypoxia combine to exaggerate cognitive impairment over time. Previous work from Ando et al. (2020) supports this explanation, emphasising the progressive decline in cognitive performance that occurs with prolonged exposure to hypoxia and physiological strain. Additionally, the increased cognitive processing time was also likely due to the effect of hypoxia on motor activity (Davranche et al., 2016). When referring to rugby union, our data suggest that decision making would be more severely hindered as playing time ensues, potentially impacting individual and team performance towards the latter stages of a game. Moreover, this highlights the advantage that native highlanders may have over visiting players, with adaptations to altitude contributing to a more sustained level of cognitive and overall rugby performance.

As expected, $S_PO_2$ was consistently lower in hypoxia (Figure 1A) but despite this compromised oxygen supply, there were no changes in heart rate, power, or RPE between conditions during this study (see Figures 1 & 2). Although this contradicts previous work implying that hypoxia induces greater cardiovascular strain and elevates levels of perceived effort (Goodall et al., 2014a). Despite this difference, the controlled nature of exercise intensity in this study (70-80% HRmax) is the likely reason for no change in cardiovascular and physical performance parameters. By standardising the workload to target a specific heart rate is the reason for similar findings across both conditions. While RPE wasn't a fixed variable in the current study, previous work suggests that in a hot hypoxic environment,

increases in RPE are driven by elevations in HR and core temperature (Levine and Buono, 2019). Thus, it can be concluded that the lack of change in RPE in the present study is explained by HR and ambient temperature being fixed variables, causing RPE values to remain consistent over both trials. It does, however, suggest that if the protocol were to be repeated at a higher intensity and for a longer duration, RPE would likely be elevated in hypoxia.

The lack of change in PPO (Figure 1C) contradicts previous work that has reported hypoxia to negatively affect maximal work (Simpson et al., 2015). This previous work used an alternative methodology (3-minute 'all out' tests) meaning their participants were sprinting for longer, compared to the 18 seconds of 'all out' effort in the present investigation. It is likely that the short-duration, maximal efforts, were predominately fuelled by anaerobic sources of energy production, masking any effects of a reduced oxygen availability. These data are confirmed by Girard et al. (2017) who report that the initial sprints in a repeated sprint activity, are almost always unchanged despite differing environmental conditions, due to the predominant use of anaerobic processes for energy production. The oxygen deficit in hypoxia is therefore somewhat irrelevant at the beginning, but would likely become a detrimental factor as the duration of these efforts lengthen and aerobic process begin to be primary provider of energy (Girard et al., 2017). It would therefore have been likely that a longer protocol, involving more sprints, would have shown differences over time; an avenue that future research should look to investigate in this population.

The similar average power in each condition is likely due to the heart rate-based intensity approach of the cycling protocol. While this once again contrasts with previous work (Amann et al., 2008), it suggests that when exercise intensity is controlled, athletes can maintain consistent performance levels. The short duration of sprints, as well as the short length of the whole protocol itself, gives potential reason to why no changes were evident between the conditions. Hypoxia has been found to have an intensified effect on repeated sprinting when phosphocreatine is unable to be fully resynthesized due to insufficient recovery periods (Faiss et al., 2013). In this case, participants may not have been fully exerted from just three sprints, with the 5-minute intervening period allowing for recovery. While athletes were able to maintain similar PO levels over the 15 minutes, this would likely differ if exercise duration was increased. By simulating a rugby-specific fatigue protocol, it is likely that a decline in performance would occur (Coutts et al., 2003). Research from Girard et al. (2017) emphasises the increased effect of hypoxia in longer, endurance-based exercise, suggesting that if the protocol were to be repeated for a longer duration (i.e. 60 minutes of a rugby match), differences

would be more pronounced between the conditions, with the effects of hypoxia causing reduced power output towards the latter stages of a match.

The findings from this study offer important inferences both cognitive and physiological processes within men's rugby union. With particular importance because of the increase in matches played in high-altitude locations (e.g. Johannesburg, South Africa), this research fills voids in literature which have yet to analyse the hypoxic effects from a cognitive perspective in a rugby union setting. The impairment of cognitive function emphasises the potential for an increase in the amount of unforced, decision-related errors which are likely to occur in hypoxic environments. As previously stressed, accurate decision making is vital in elite rugby union (Ashford et al., 2021), with errors in this domain, or a lack of, capable of deciding the outcome of a match. Therefore, decrements in reaction time during the course of a match played at altitude, may hinder players' ability to read game-specific scenarios such as defensive setups or passing plays. Recommendations from this work could be given to coaches to consider implementing cognitive training in hypoxia, in preparation for matches played at altitude. This could eliminate submaximal cognitive performance, as well as develop physiological systems that would likely be challenged over the course of 80 minutes. Published work shows that pre-exposure to a hypoxic environment elicits improvement in cognitive performance (Lin et al., 2024) via increased cerebral oxygenation and neurovascular coupling (Mateo-March et al., 2022), giving positive evidence to suggest that time spent training at altitude, or simulated altitude, would be beneficial to rugby union athletes in preparation for away matches.

*Limitations*

Despite the changes seen in cognitive function, a limitation of this study was a relatively small sample size ($n$ = 7). Just over half of a standard team number were recruited and future studies should acknowledge player positions, as cognitive function and task complexity are known to differ between forwards and backs (Ashford et al., 2021). Additionally, despite the Stroop test being a reputable method of cognitive assessment, particularly for decision making, a rugby-specific protocol for this outcome measure would have been more appropriate and could have simulated in-game decisions to greater effect. This would have allowed for a greater understanding of the way hypoxia influences the decisions that occur in a game scenario. It is also worth noting that despite spacing out trials in different conditions by at least one week, a learning effect may have been a factor in participants' ability to complete the Stroop test. By becoming somewhat accustomed to the process of working out answers, both between sprints and between trials, there must be consideration given to this parameter.

*Conclusion*

The novel finding of this work was a reduced cognitive performance in hypoxia, characterised by longer times to complete the Stroop test. The difference in physiological function was stark, with large differences in arterial oxygen saturation, however, no differences were apparent in any other outcome measure (HR, RPE, and PPO). These data confirm that player decision making is negatively affected by altitude, likely due to reduced cerebral oxygenation driving the cognitive impairment. Our findings infer that while rugby union players may be capable of maintaining physiological stability over short durations at altitude, their cognitive ability may be inhibited, resulting in potentially handicapped decision-making during high pressure game situations.

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## Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to data restrictions, namely survey responses containing information that could compromise the anonymity and privacy of research participants.

## Conflicts of Interest

There are no relevant financial or non-financial competing interests to report.

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## Research Article

# Implementing the 3+1C model in dyadic relationships outside of the elite sport domain

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Running Title: Coach Athlete Relationship Beyond Elite Sport

## Abstract

Developing a high-quality coach-athlete relationship (CAR) has been shown to impact athletes' performance, motivations, and satisfaction. However, there is limited evidence regarding the implementation of the CAR framework (3+1C model) in other dyadic relationships (e.g., boss-employee, trainer-client, leader-follower) outside the elite sport domain. Implementing the 3+1C framework outside the elite sport domain can help leaders and followers build high-quality relationships. This pilot study used the 3+1C model (i.e., closeness, commitment, complementarity, and co-orientation) to explore how current and future kinesiology and health-based leaders are currently or plan to develop high-quality relationships with their followers. Our sample included 15 participants (n = 9 females), divided into three focus groups. There were five categories and six themes that resulted from this work. Results showed that creating psychologically safe, caring environments, was a way leaders could enhance their relationship quality. Additionally, leaders believed that using effective communication strategies and transformational leadership also aided in developing high-quality relationships. In contrast, disengagement from the leader and perceptions of creating an ego-involving climate were seen as negative and detrimental to developing quality relationships between a leader and a follower. Our findings emphasize the significance of educating leaders (e.g., coaches, bosses, instructors, and teachers) and hosting organisational interventions based on teaching components of effective communication along with creating adaptive rather than maladaptive climates within a kinesiology and health setting. Educating leaders and promoting change in their leadership styles can impact a follower's motivation, performance, relationship with their leader, and well-being.

**Keywords:** caring climate, coach-athlete relationship, COMPASS model transformational leadership.

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# Introduction

Since the early 2000s, there has been increased interest in the phenomenon known as the "coach-athlete relationship" (CAR; Davis & Jowett, 2014; Jowett, 2025; Mageau & Vallerand, 2003). This relationship has been deemed central to effective coaching, while also being a fundamental precursor of athletes' optimal functioning (Davis & Jowett, 2014). Scholars have been interested in discovering how one can nurture motivation in athletes to impact their experiences and performance (Jowett, 2025; Mageau & Vallerand, 2003; Pan & Sui, 2025). These studies have shown that although there are multiple different factors that affect the motivations of athletes, the CAR is one of the most important influencers on athletes' motivation and performance (Jowett, 2025; Mageau & Vallerand, 2003; Pan & Sui, 2025). However, it is important to acknowledge that there are several types of dyadic relationships within sports and exercise (e.g., instructor-exerciser, assistant coach-head coach, and referee-athlete). One area explored is the parent-athlete-coach triangle (Santos et al., 2024; Tagliavini et al., 2023). For example, it was highlighted that parent-coach proximity helped to enhance the sporting experience within this triad (Tagliavini et al., 2023). Additionally, college athletes have expressed that increased levels of openness with their faculty members have helped improve their academic performance; thus, quality relationships are a vital component for success on and off the playing surface (Brouwer et al., 2022). However, it is thought that understanding the quality of these varying sports and non-sport relationships remains an untapped area within dyadic relationship research (Jowett, 2025: Snijders et al., 2018). While other models have conceptualized the CAR, such as LaVoi's (2004) and Poczwardowski's et al. (2002) conceptualized models, the most well-known and widely used model that has investigated the quality of the CAR is the 3+1C model, as it has shown success when applied to relationships in and outside sporting domains (Bates & McShan, 2025; Jowett, 2025; Jowett et al., 2023).

*What is the Coach-Athlete Relationship?*

The definition of the quality of CAR is a situation where a coach's and an athlete's cognitions, thoughts, and behaviours are mutually and causally interrelated (Jowett, 2025). Researchers often describe the CAR quality using terms such as commitment, cooperation, communication, bonds, respect, friendship, power, dependence, dislike, and distrust (Jowett, 2005; Poczwardowski et al., 2002). The relationship that a coach has with their athlete can be utilized by the coach as a foundation for the growth of an athlete, both socially and emotionally (Poczwardowski et al., 2002). The lack of a quality relationship can lead to disconnection, isolation, loneliness, and separation between a coach and an athlete. These outcomes are likely to affect accountability, responsibility, and ownership, all necessary characteristics for the growth and development for both the coach and the athlete (Jowett, 2025).

The responsibility of a coach has extended past the traditional playing field, as it is being discovered that the relationship between a coach and an athlete has the potential to guide an athlete's career development (Pan & Sui, 2025). It is also important to note that the coach is an important member of the sport-related social environment with the potential to positively impact outcomes of the psychological health of an athlete (McGee & DeFreese, 2019). Research has proven that the quality of this relationship is a vital contributing factor to the athletes' satisfaction, motivation, and performance, therefore highlighting the significance of developing a high-quality CAR (Jowett, 2025; Mageau & Vallerand, 2003).

*The 3+1C Model*

In the early 2000s, several frameworks were developed to attempt to explain the relationship between a coach and an athlete, including Wylleman's conceptual model (Wylleman, 2000) and Poczwardowski's conceptual model (Poczwardowski et al., 2002). However, Jowett et al.'s creation of the 3C and 3+1C conceptual models are perhaps the most notable models when it comes to dissecting the intricacy of the CAR (Jowett, 2005; McShan & Moore, 2023). The 3+1C model aims to describe the quality and content of the CAR (Jowett, 2007). It has been operationalized using the dimensions of closeness, commitment, complementarity, and co-orientation (Jowett, 2007; Zhao & Jowett, 2022). Closeness refers to feeling emotionally close to one another in the CAR, encompassing trust, respect, liking and appreciation (Jowett & Ntoumanis, 2004; McShan & Moore, 2023). Commitment describes the intention of both athletes and coaches to maximize and sustain their relationship over time (Jowett & Ntoumanis, 2004). Complementarity is synonymous with collaboration, which involves understanding expected roles within the relationship (Jowett, 2025; Jowett & Ntoumanis, 2004). This dimension of the CAR can be thought of as friendliness, acceptance and responsiveness (Jowett, 2025; Jowett & Ntoumanis, 2004). Co-orientation represents the +1 of the model and refers to the common ground or shared knowledge and understanding between a coach and an athlete when it comes to each other's roles, beliefs, values, and aspirations (Jowett, 2007, pp. 64-65).

*The Importance of High-Quality, Positive Relationships Outside of the CAR*

While several studies reveal the benefits of a high-quality CAR using the 3+1C model, there is a gap in assessing relationships with this same model outside CAR, as well as between coaches and athletes at lower levels of competition (Jowett et al., 2023; McShan & Moore, 2023). Understanding the use of the 3+1C model in other non-elite sport settings is a warranted area of research because positive, high-quality relationships have been associated with one's overall well-being (Jowett, 2025). Bates and McShan (2025) conducted research on a population of high school student-athletes post-COVID-19

pandemic, and their findings highlight the value of high school coaches in creating caring, task-involving climates while also prioritizing the personal growth, autonomy, and overall well-being of student-athletes. Another study, conducted by Jowett et al. (2023), investigated the quality of the teacher-student relationship within an educational setting, adapting the coach-athlete relationship questionnaire (CART-Q; Jowett & Ntoumanis, 2004) to create the teacher-student relationship quality questionnaire (TSRQ-Q). The study found that students in both mathematics and physical education settings who perceived their relationship with their teacher as characterized by the 3 C's (closeness, commitment, and complementarity) reported significant positive correlations, such as with positive affect, perceived competence, and enjoyment (Jowett et al., 2023). Other scholars have also used the 3+1C model and found that creating quality relationships with professors can enhance academic motivation for collegiate student-athletes (McShan & Smith, 2026). Researchers called for this framework to be used in other domains to discover how aspects of the 3+1C models help researchers and practitioners to understand how individuals plan to create quality relationships (Jowett, 2025; Jowett et al., 2023).

One such area that could warrant investigation into the legitimacy of using the 3+1C model is within the field of kinesiology and health sciences. Within the related fields, individuals pursue careers such as physical therapists, nurses, doctors, occupational therapists, chiropractors, and exercise physiologists. Past research has highlighted that being employed within these health, sport, and wellness careers requires the development of quality relationships, and when these relationships are absent, it can affect the quality of these relationships (Dinç & Gastmans, 2013; Hall et al., 2010; Wu et al., 2022). Similar to the use of the 3+1C model, relationship quality has been investigated using practitioners, patients, clients, coaches, and athletes already within their respective fields (McShan & Moore, 2023; Wu et al., 2022). Therefore, an under-researched area is how kinesiology and health sciences early-career professionals or aspiring professionals plan to develop quality relationships with the patients, clients, and athletes that they may interact with.

The purpose of this investigation was to understand how early-career and future health science and kinesiology-based professionals plan to implement aspects of the 3+1C model outside elite sport. Additionally, the majority of work using the 3+1C model has been conducted in the sports setting with coaches and athletes. To expand the use of the 3+1C model, examining other contexts beyond coaches and athletes is warranted (Jowett, 2025; McShan & Moore, 2023; McShan & Smith, 2026). It is important to acknowledge the significance of leaders building positive, high-quality relationships with their followers. Achieving such may lead to positive experiences, higher levels of pleasure, and greater

engagement in an individual's sport or career (Jowett, 2025; Mageau & Vallerand, 2003; Pan & Sui, 2025).

# Methods

*Context, Recruitment, and Sample*

Ethical approval for this study was provided by the authors' Institutional Review Board IRB-FY2026-69. To maintain confidentiality and anonymity, all participants' data were stored on a password-protected server accessible only to members of the research team. Additionally, all participants were given pseudonyms to protect their identities. The only identifiable data collected was individuals' email addresses used to schedule focus group times, which only members of the research team had access to. The study was a qualitative research investigation that used focus groups to examine the aspects of the 3+1C model. Researchers conducted three focus group sessions with 15 participants aged between 18 and 43 years. Focus group one consisted of seven participants, focus group two included five participants, and focus group three included three participants. The sample included 6 males and 9 females who have all participated in sports throughout their lives; 14 participants were affiliated with the research teams' home institution. Within the study, there were 11 different academic majors represented within the focus groups (e.g., physical education, biology, and nursing). Twelve of the participants noted that they are either current or future professionals in sport, exercise, and health. Three of the participants were not interested in becoming a future professional in sport, exercise, and health; Table 1 outlines full demographic information.

For this study, interviewers were asked to recruit participants from a convenience sample (Winton & Sabol, 2022). Along with emails being sent to students in the exercise science department at the researcher's home institution. Emails were also sent to professors, instructing them to ask their classes if they would like to participate. Social media was also used to promote the study, asking viewers of social media posts to join the study. All participants were recruited within a Midwestern state. Prior to the start of the interview process, all participants completed an informed consent and demographic survey. On the date of the interviews, a private room was reserved in the university classroom for the interviews to take place. Before each interview with the respective focus groups, researchers read the participants in a verbal interview schedule script, which allowed participants to understand the purpose and structure of the focus group interview. Once consent was given, audio recording began and the formal focus group interviews began, which lasted between 30-45 minutes. Participants were entered into a drawing for 1 of 25 $15 gift cards as an incentive for participation in this study.

**Table 1.** Participant demographics.

| Name | Age | Participant Sex | Ethnicity | Home Country | Education Level | GPA | Focus Group |
|---|---|---|---|---|---|---|---|
| Ashton | 21 | M | White | USA | Senior | 3.8 | 1 |
| Adam | 28 | M | White | Unknown | RG[1] | N/A | 1 |
| Maria | 21 | F | White | Brazil | Senior | 3.25 | 1 |
| Eva | 18 | F | White | England | Freshman | 3 | 1 |
| Lilli | 18 | F | White | Germany | Freshman | 3.5 | 1 |
| Lana | 20 | F | White | USA | Sophomore | 3.85 | 1 |
| Brian | 23 | M | White | Unknown | RG[1] | N/A | 1 |
| Amber | 23 | F | White | Unknown | RG[2] | N/A | 2 |
| Madison | 22 | F | White | USA | RG[1] | 4.0 | 2 |
| Jacob | 43 | M | White | USA | Unspecified | 3.0 | 2 |
| Zander | 25 | M | White | USA | Graduate Student | 3.73 | 2 |
| Mary | 21 | F | White | USA | Senior | 3.86 | 2 |
| Clint | 21 | M | White | USA | Graduate Student | 3.86 | 3 |
| Ellie | 21 | F | White | USA | Senior | 3.87 | 3 |
| Sophia | 19 | F | White | Brazil | Freshman | 3.75 | 3 |

*Note.* M = male; F = female; RG = recent graduate; [1] = 2025; [2]= 2024; N/A = not applicable

*Semi-Structured Focus Group Guide*

This study was performed using a semi-structured focus group design. The design of the study was chosen for simplicity and adaptability for individual answers. The interviewers asked broad questions allowing for individual responses in order to extract opinions on how the 3+1C model could be used to foster quality relationships between participants and leaders in the fields of kinesiology and health sciences. The study team was divided into different roles for the interviews. There were two interviewers who were leading the discussion using an interview guide, including suggested questions. There were two individuals who were tasked with recording the interviews and getting a proper transcript of the entire interview from start to finish. And finally, there were two individuals who were tasked with taking notes on anything that they might have seen that needed to be noted during the interviews. With each of the researchers assigned to their own duty, interviews were conducted. Participants were able to respond in their own words by using open-ended questions in order for them to give their own input. Participants were guided using the following sample questions included:

a. What is the first thing that comes to mind when you think of a really good relationship with someone?

b. What first comes to mind when you think of a good quality relationship with a sports exercise or health leader or coach that you've had?

c. Let's look back at a coach or exercise professional that you had a negative relationship with, tell us about that.

d. How will you develop closeness as a professional in your field?

*Reflexivity and Positionality*

In our qualitative design, reflexivity was a vital element, as researchers acknowledged their own perspectives and potential biases throughout the study. With each of the members of the research team having a background in similar fields, we acknowledged the possibility of biases towards the information included in the study. Our group was constructed of six graduate students and one professor, four females and three males, all with differing student and career statuses. Each graduate student was pursuing a career in the kinesiology field, whether that be as a coach, instructor, or academic advisor. The research team included three graduate assistant coaches (i.e., strength and conditioning, tennis), a graduate assistant lab instructor in the kinesiology department, another intern with the strength and conditioning department, and finally an advisor with the athletic academic advisement staff, and one professor. With this information of the research teams' background, our participants were encouraged to recall their own lived experiences and were informed there are no right or wrong answers to our questions. All research members took part in a bracketed interview to test out interview procedures as well as to see any biases that individuals had related to the research question. Prior qualitative research has also used the procedure of conducting a bracketed interview to reflect on personal biases (McShan & Salem, 2026).

*Data Analysis*

The data collected from the three focus group sessions was analysed using a qualitative approach. Approximately 18 pages of transcripts from the interviews were placed into data analysis software (Dedoose v10.0.59, Sociocultural Research Consultants, LLC; CA USA). The analysis procedure followed past qualitative focus group procedures that used inductive procedures and thematic analysis to lead to creating initial themes and list of emerging codes (Bates & McShan, 2025; Guba & Lincoln, 1994; Strauss & Corbin, 1990). Using data from Dedoose, codes were created to analyse themes and patterns that may have occurred within the interviews. After responses were placed into unique codes, each page of the transcripts was analysed and placed into categories in which they fit into (i.e., the dimensions of the 3+1C model). Using the Dedoose report, we were able to find trends in which the participants answered their questions. This report also allowed us to organize statements from multiple participants that sounded or looked the same into similar themes. Next, using the software, we deleted and restructured our themes to the version that resulted in a high level of agreement

among the peer coders, by using a codebook to organize categories and themes. Finally, researchers extracted highlight/hero quotes to showcase how these quotes best represent the categories and themes.

# Results

Results indicated that there were six themes within five categories that helped to explain the quality of how future and early career kinesiology-based and health sciences leaders plan to develop quality relationships with those that follow them. Table 2 summarises the associated themes with exemplary quotes included. Creating a safe and caring climate, and second, disengagement as a leader and an ego-involving climate represented the first two themes within the category of all the dimensions of the 3+1C model. The dimensions/categories of closeness, commitment, and complementarity each had distinct themes that participants described as important for developing this aspect of relationship quality. Co-orientation remained its own dimension/category with no themes associated within it. The themes of idealised influence and effective communication were identified within closeness. Intellectual stimulation was identified as a theme within commitment, and openness was identified as a theme within the dimension of complementarity.

*Safe and Caring Climate*

Many participants discussed the importance of making athletes feel welcome, safe, and supported. From focus group one, Ashton noted, *"being personable, like really trying to relate with them, even if there's like, a big age difference, like just trying to show them that you mean business, but in a relatable way…"* is a crucial step of building a caring climate. Participants not only focused on the importance of leaders creating a caring climate, but also the benefits of athletes supporting their fellow teammates. The importance of creating a safe place for athletes/participants was also established. Making sure all athletes feel as though they are important, and that genuine connection is established within the team dynamic. Many participants expressed that when a leader, or coach, would allow them to be authentic and have fun, it encouraged them to relax and feel safe.

*Disengagement and an Ego-Involving Climate*

Throughout our study, many positive traits and experiences were expressed in how emerging leaders best thought to develop quality relationships with followers. However, our next theme emphasises the repeated negative concept that continued to come up, which was that of disengagement from the leaders and leaders who create an ego-involving climate. Many participants expressed that one way to hurt the quality of the relationship with a follower was when the leader is disengaged during

competitions and practices. When a leader is disengaged, it leads to ineffective outcomes. Most of the participants agreed that it made them feel like the coach wasn't committed to them. One participant, Zander from focus group two, expressed, *"When I ran cross country, our coach was not interactive with us at all. [He would just be like] All right, here you go, here's what we're doing. Go do it. Won't critique anything. Just zero coaching there."* When a coach shows disengagement due to lack of leadership, chooses not to say something to help a struggling individual, it doesn't allow participants to grow as an athlete, but also as a person. One participant Zander from focus group two commented, *"Giving feedback quickly and not waiting to tell someone what they are doing wrong."* Most participants within Zander's focus group agreed that when the coach didn't disclose feedback back to them, they didn't feel like they were growing as athletes. One participant Ellie who was a part of focus group three, expressed, *"If a coach isn't giving you any critiques, they['ve] given up on you."* Therefore, a negative aspect that emerging and current leaders expressed within this study is that having a disengaged leader may lead to lower relationship quality with their followers.

Many participants expressed that they believed as a leader if you create an environment that followers have perceptions of being in an ego-involving climate led to less commitment from most athletes/followers and didn't feel safe in their environment. Part of an ego-involving climate involves a leader who punishes individuals for mistakes, instead of seeing mistakes as part of the learning process. When talking about the coach that yells/is negative all the time, Clint from focus group three expressed, *"I don't respond well, I don't like that, that's not positive."* Another participant, Mary from focus group two, expressed, *"I have had coaches who have made me afraid to fail, they push you away and say things like you are un-coachable, then give up on you."* Most of the participants would nod their head and agree that the ego-involving climate didn't contribute to quality relationships with the coach/leader of the team that they were on.

*Closeness*

Each of the three dimensions of the 3+1C model of closeness, commitment, complementarity, and co-orientation are presented next. Within each of these dimensions, the associated themes are presented. Beginning with closeness, the themes of how the leaders plan to develop it were thought to be shaped by idealised influence and effective communication. Idealised influence participants expressed the importance of having someone to look up to as a role model within a kinesiology and health sciences setting. Ellie from focus group three discussed that, *"Sometimes people just aren't pleasant to be around. [It] just feels like everybody's mad at each other. [Leaders should]... just lead by example, you know... show they care for the people that you're around and working with."* A leader

that serves as a role model also known as providing idealised influence may help to develop closeness with participants/athletes and their leader.

It is important to note that many of the characteristics the focus groups deemed important went both ways, so within the second theme, within closeness, leaders must use effective communication strategies to develop quality relationships between leaders and followers in kinesiology and health environments. Ellie from focus group three went on to discuss that leaders and athletes should: *"Start small, break the ice with the athlete, get to know the person, then they are more willing to share with you the deeper things that are going on in their life".* Which is what is important, them seeing themselves as a full person, unique person, not just a person that is there playing that sport.

One way coaches/leaders can show effective communication strategies is by relating to followers on a personal level. Allowing athletes/followers to see themselves as human beings who go through the same life experiences as the leaders do, leaders believed, helped their followers feel that they are not alone in what they are going through, which can improve closeness between athletes/followers and coach/leaders. As Ashton from focus group one said, *"Be personable, really try to relate with them, even if there's a big age difference, relate to them, and understand what is happening in their lives outside of the sport."* The theme of effective communication was thought to help current and emerging leaders develop the aspect of closeness within their leader-follower relationship.

*Commitment*

In the 3+1C model, commitment is the desire to maintain the relationship over time. It is an agreement to achieve a goal together, experience both ups, downs, wins and losses, yet still sticking together. The lone theme related to the commitment dimension was intellectual stimulation. In order for followers to be committed to leaders, kinesiology and health-based participants within this study believed that displaying intellectual stimulation with their leadership (e.g., challenging followers to think critically) helped improve commitment quality. This theme is highlighted by Jacob from focus group two, who said, "*Always [being] able to make somebody feel good about their failure. Yeah, what did you learn from that [failure]? How did you grow from that? Like, what are we going to do differently next time?"* Having followers be able to critically examine and grow as individuals is a key point of why intellectual stimulation may help to enhance commitment quality between leaders and followers in a kinesiology and health setting.

*Complementarity*

Participants expressed the importance of complementarity throughout the interview, expressing how collaborating and working together is crucial for success for leaders and followers within a kinesiology and health-based setting. The lone theme that was associated with complementarity was that of openness. One participant, Lana from focus group one, shared the following related to openness: *"As a personal trainer, I tell people all the time like, half my job is being their therapist. So feeling like they [the clients can] talk to me about anything, and they know I won't, you know, tell anyone else. Like it's safe with me, really helps me build super strong relationships and connections with these people. And it's just funny sometimes because I. I feel like these people don't have anyone else that they can talk to about this stuff, and so I just feel super like, just valued in a way, rather than just like, telling them, you know what exercises to do it like, gives me another purpose. And I feel like building those strong relationships."* Displaying openness within a leader-follower relationship may help to develop high-quality relationships based on the complementarity dimension of the 3+1C model.

*Co-orientation*

Although our research interview guide did not specifically ask questions about co-orientation, our results showed that our participants believed the +1 of the 3+1C model was essential in creating relationship quality with their followers. For instance, Lana from focus group one commented, saying, *"Finding…the group…goal like that everyone can, agree upon and like feels that everyone needs…[to] push towards, is like, something that you can work for together, so it feels like it's a group thing."* The emphasis on common goals is a central component of the co-orientation dimensions within the 3+1C model.

**Table 2.** Themes and Subthemes.

| **Full Measure of the 3+1C Model** | | |
|---|---|---|
| **Theme** | **Definition** | **Sample quotes** |
| Creating a Safe and Caring Climate | Describing leaders who create interpersonally inviting, safe, supportive environments where they feel valued and respected. | "Making sure they're [athletes/followers] comfortable and like they feel welcomed…making sure there's things that make them feel like it's like their home, kind of creating that safe space and safe environment for them" - Lana from focus group one.<br><br>"I think the moment that they realize that you're actually engaging with them and that you care, and you show that you care about them. You are going to start creating friendships/good relationships, quality relationships." – Maria from focus group one. |
| Disengagement and an Ego-Involving Climate | An environment where the leader is unengaged or a leader who has favorites and non-favorites, punishes mistakes, and promotes success only when achievement is made. | "My least favorite thing is when somebody, when you're having a conversation with someone, and you respond, and they just keep talking about what they were saying." -Ellie from focus group three<br><br>"I feel like I've had coaches that have made me [you] afraid to fail, which I feel like is not something you want in your athletes. I feel like you want them to be able to have room to grow and be able to fail so they can learn from it." -Mary from focus group two. |
| **Closeness** | | |
| **Theme** | **Definition** | **Sample quotes** |
| Idealized Influence | A leader who acts as a positive role model, gaining the followers' trust and respect | "[As a leader demonstrating] patience is something that is something good a coach can have. Not feel like you're going to be aggressive to an athlete if they come with you with a minor inconvenience, just like, okay, might not be able to come and practice understanding." -Zander from focus group two.<br><br>"Not everything is always good…while you might be on a winning streak…the person sitting next to you could have just failed a test or something. So not everything might be great. So just making sure [as a leader] that…you're still checking in on those things. Yeah, hey, like, how was that test? I know you're stressed about it, making sure that they're heard, cared about." -Ellie from focus group three. |
| Effective Communication | Leaders who use proactive ways to relate and communicate with their followers | "Tell them [your athletes], like, communicate that they're doing a good job, but then also, like, not puff up their ego, like, remind them, like, yeah, you guys are winning, but remind them of, like, how hard it is to win. Like, it's there's a lot of work that goes into winning. The reason why you guys are winning is because you're putting the work every single day and just reminding them to keep on doing that and try to keep them on track." -Adam from focus group one. |

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| | | "I think most people want that kind of passionate, active, sympathetic ear, especially from their boss, but not everybody, and being able to identify the people who just want to be left alone and treat them, you know, well, but differently than the type A personalities…making people feel good about what they've done, and what they what they can do." -Jacob from focus group two. |
| **Commitment** | | |
| **Theme** | **Definition** | **Sample quotes** |
| Inspirational Stimulation | A leader who challenges followers to think in an independent, critical, and creative manner | "[As a leader] you have to continue to remind them, like, in the middle of the season, if you're on like, [on] a five-game win streak, the job's not finished, even if your season's technically over, you just got to keep going. Like, you can't just give up because your season's over, but you're hot and you can't give up because you win X amount of games in a row, because typically like success is measured by what you said at the end of season. So if success is a championship, then you can't stop until that's what you get."- Ashton from focus group one.<br><br>"Trying new things, like showing that you're like, willing to like, adjust and adapt to like the situation." – Lana from focus group one |
| **Complementarity** | | |
| **Theme** | **Definition** | **Sample quotes** |
| Openness | The leader being willing to share information and maintain a good level of communication. | "People that you're working with, or [on] your team…in the planning of things… [As a leader] being open to their opinions also, because you know, just because you're maybe above them doesn't mean you know everything, and maybe they have some good ideas that you wouldn't have thought of." – Mary from focus group two<br><br>"Giving feedback like, quickly, not waiting on something like, Oh, you did something a week ago. Now I'm gonna…give you advice to help you out. If you have you seen something that I'm doing wrong, inform me, tell me, immediately." – Zander from focus group two |
| **Co-orientation** | | |
| **Category** | **Definition** | **Sample quotes** |
| Co-orientation | Cited in the introduction | "Make sure that they [the athletes] have, like, the buy-in, because, like, at the end, like you have that goal. I mean, for you guys in softball, it's like, you know, winning a championship. Make sure that everybody has that buy in, into those common goals." – Clint from focus group three.<br><br>"I know for our team, we set goals at the beginning of our season, and then we hold each other accountable to it. So it's not just a 'Oh, hey, we're just going to do this workout today, but reminding ourselves what our goals are. So being goal-[oriented]. Allowing the team to set these standards and having a leader that inspires them to reach these goals." – Madison from focus group two. |

## Discussion

The purpose of this study was to explore how early-career and future kinesiology and health sciences professionals planned or are currently creating quality relationships with patients/clients/athletes they will or are interacting with, using criteria related to the 3+1C model. From the three focus groups, six themes emerged from the five categories of the 3+1C model as a full measure, closeness, commitment, complementarity, and co-orientation. The themes for the full measure of the 3+1C model were: creating a safe and caring climate, as well as limiting disengagement from the leader and creating an ego-involving climate. Two themes were linked to closeness, which were idealised influence and effective communication. The theme associated with commitment was intellectual stimulation. For complementarity, there was one lone theme of openness. Co-orientation had no associated theme, but it was still a key finding within our research.

Our present study adds two main contributions to the relationship quality literature. First, this research adds to the 3+1C framework by applying the idea to an array of different individuals, including university students, athletes, and professionals within the health sciences field. Our study examines the 3+1C model's applicability to relationships beyond the traditional CAR it is normally associated with (Jowett, 2025). Our work built on the work of the creation of the TSRQ-Q (Jowett et al., 2023). Specifically, where Jowett et al. (2023) showed that aspects of the 3+1C model could be applied quantitatively to a different dyadic relationship outside the CAR, our work confirmed these findings qualitatively by involving leaders from settings beyond traditional and elite sport. Second, the qualitative findings illustrate the connections among the individual dimensions of the 3+1C model, an area that has been noted to require more robust evidence (Jowett, 2025). As such, the study provides a better understanding of how the fundamental elements of the 3+1C model interact in various relationship scenarios.

The present findings have been linked to other core concepts within the field of sport and exercise psychology, such as psychological safety, the creation of more adaptive than maladaptive climates (Fry & Moore, 2019), transformational leadership, and the COMPASS Model (Rhind & Jowett, 2010, 2012). Psychological safety in sports has been positively associated with high-quality CARs (Gosai et al., 2023; Weng & Cheng, 2023). However, prior studies have quantitatively linked psychological safety to the quality of the CAR using the full measure and subscales of the CART-Q. Our work qualitatively links these findings. Therefore, our work helps confirm some well-established literature that, to support high-quality relationships, whether inside or outside a sporting domain, it is the leaders' responsibility to make their followers feel psychologically safe.

Motivational climate researchers have long advocated for environments such as within the classroom or in a sporting domain for leaders to create adaptive environments that focus on creating task-involving (e.g., leaders who see mistakes as part of the learning process, value personal effort and self-improvement) paired with a caring climate over a climate that is ego-involving (e.g., punishes participants for making mistakes, leaders who have favourites and is more performative in nature) (Breske et al., 2017; Fry & Moore, 2019; Hogue et al., 2019, 2021; Iwasaki & Fry, 2016). Perceptions of creating a task-involving and caring climate have been linked to greater sport enjoyment, intrinsic motivation, and effort among athletes (Fry & Moore, 2019). Whereas perceptions of an ego-involving climate have been negatively associated with athlete enjoyment and athletes' competence (Fry & Moore, 2019). These findings are consistent with studies showing that both caring and task-involving climates enhance followers' well-being, moral behaviour, and intrinsic motivation (Fry et al., 2023). These findings correspond to the literature suggesting that negative forms of leadership lead to a decrease in athlete satisfaction and performance (Liu et al., 2025). While past research has highlighted the association between CAR quality and the task-involving and caring climate associated with the 3+1C model, this information remains limited, and more research is needed in this area (McShan & Moore, 2023; McShan & Salem, 2026; Olympiou et al., 2008). Thus, our work adds to the limited knowledge of the association between motivational climates and the use of the 3+1C model.

Numerous participants highlighted leaders who inspired, modelled the behaviours they valued, and created a vision to engage in shared goals; this aligns with how transformational leadership constructs have previously been articulated (Álvarez et al., 2019). In our study, two aspects of transformational leadership emerged as particularly strong: idealized influence and intellectual stimulation. Past research has reported mixed results regarding the 3+1Cs' association with intellectual stimulation, with the strongest association being with closeness (Gosai et al., 2023), whereas another study found that commitment had the strongest association with intellectual stimulation (Zhao & Jowett, 2022). In our study, we found only the theme of intellectual stimulation associated with the commitment dimension. Therefore, there may be a need to gain further insight into which dimension of the 3+1C model best aligns with providing intellectual stimulation. While research has highlighted links to the 3+1C model and aspects of transformational leadership, none of these studies have included idealized influence (Karayel et al., 2024; López de Subijana et al., 2021; Zhao & Jowett, 2022). Therefore, our study helps to add to the literature that, specifically for the dimension of closeness, as a leader, it may be advantageous to display aspects of idealized influence and intellectual stimulation to your followers in a kinesiology and health-based setting.

The use of communication strategies, such as effective communication and openness, was highlighted in our research as an important factor in how future kinesiology-based and health sciences workers could achieve high-quality closeness and complementarity within their leader-follower relationship. Within the 3+1C model literature, effective communication strategies to maintain quality relationships have been linked to the COMPASS model (Rhind & Jowett, 2010, 2011, 2012). The COMPASS model offers particular strategies that leaders can take to establish and maintain connections with their followers. The strategies of this model include conflict management, openness, motivational, preventative, assurance, support, and social networks. Therefore, our study is one of the first to link aspects of the COMPASS model to non-CAR dyadic partnerships. The COMPASS model provides clear and easy behavioural ways for leaders to enhance closeness, increase commitment, and build complementarity, which further evokes the applicability of the 3+1C framework to understand dyadic relationships outside of the CAR domain.

Jowett (2025) discussed the need to better understand the dimensions of co-orientation with scholars' work related to the 3+1C model. Several prior studies have looked at only the 3Cs of the 3+1C and have neglected examining the +1 of the model, which is co-orientation (McShan & Salem, 2026; McShan & Smith, 2026; Vella et al., 2013; Zhao & Jowett, 2022). Our work helps us start to achieve that goal, as it highlighted that the use of common goals, a key component of co-orientation between leaders and followers, was thought to enhance relationship quality. As scholars continue to advance the work of co-orientation in relation to the 3+1C model, other aspects of co-orientation should be explored, such as shared knowledge (Jowett, 2025).

*Practical Implications*

The results come with very important implications for the training of kinesiology and health science leaders. The future training of these leaders should focus on intentionally building a caring climate as a key condition for quality relationships with followers. By doing so, leaders may be able to create an environment that enhances followers' engagement by increasing perceived social support. Therefore, training should be focused on teaching how to provide emotional and social support that will foster a psychologically empowering environment that can sustain intrinsic motivation and long-term engagement (Li & Xing, 2025). By helping leaders be trained in how to create these effective climates, leaders may be less likely to create perceptions of an ego-involving climate or disconnectedness within the leader-follower relationship.

Future leaders within a kinesiology and health setting will want to learn to develop their leadership and communication skills. By cultivating leadership skills focused on being a positive role model and helping individuals think critically, these leaders may enhance the quality of closeness and commitment within their leader-follower relationships. As well as focusing on training that helps improve communication skills outlined by the COMPASS model, it may also help to enhance relationship quality with followers.

*Limitations and Future Directions*

There were limitations present within the investigation that are important to address. First, the sample size was limited due to inclement weather on the day of the focus group interviews. This impacted the amount of data we were able to collect. Best practices in focus group research call for there to be at least four focus groups and at least six members per focus group (Ahmed, 2025; Folch-Lyon & Trost, 1981). Additionally, this research was a part of a graduate sport and exercise psychology course requirement, thus researchers were limited to conducting and finishing this research during one academic semester. Future research should follow best practices and try to have at least four focus groups with at least six participants in each of the focus groups. Second, the lack of participants resulted in our focus group's insufficient representation of the “leader” (coaches, trainers) perspective of the research. Future research may include larger sample sizes with the inclusion of greater amounts of diverse individuals from different geographical areas and various leaders within different fields (e.g., fitness instructors, coaches, academic advisors) to confirm the wider applicability of these themes. Additionally, most of the researchers who conducted this study were graduate students who were novices in qualitative research. However, giving students who would not otherwise have engaged in the scholarly process an opportunity to conduct research was seen as a positive learning experience by most researchers within this study. Moreover, it will be necessary to conduct longitudinal studies that focus on relationship quality. Lastly, researchers could use dyadic methods, which measure both dyadic members’ perspectives, thereby providing a complete picture of both the absolute and relative views of the relational quality.

*Conclusion*

This research offers qualitative results that the 3+1C model is a useful and applicable tool in the analysis of coach/leader-athlete/follower relationships within and outside of the sport and exercise domain. One can see that by following the 3+1C model, a leader can cultivate the necessary atmosphere to allow their followers the best chance to flourish. These outcomes gain strength when the followers engage and accept the coaching process. The willingness to cooperate allows the

relational pieces of the 3+1C model to take root. The results highlight the importance of creating a caring climate along with relations rooted in closeness, commitment, complementarity and co-orientation. It is clear that shifting away from harmful coaching practices that emphasize creating an ego-involving climate is crucial to building a healthy bond between leaders and their followers. When leaders practice and apply these qualities, they gain the ability to impact the engagement, motivation, and overall positive experiences of their followers. Strengthening these factors clearly increases followers' success and enables a high-quality leader-follower relationship.

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## Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to data restrictions, namely survey responses containing information that could compromise the anonymity and privacy of research participants.

## Conflicts of Interest

There are no relevant financial or non-financial competing interests to report.