A comparison of men's and women's physical performance assessed using an identical profiling protocol in professional soccer: Considerations for targeted S&C.

Colin Clancy, [1] **Matthew Fenwick,** [1] **Adam Owen,** [2 3] **Aaron Gilfillan,** [1] **Kieran Duffie** [1]

[1]Physical Performance and Nutrition Department, Hibernian Football Club, Edinburgh, UK
[2]University of Lyon, University Claude Bernard Lyon, Villeurbanne, France
[3]KKS Lech Poznan, Poznan, Poland

Aerobic performance | **Speed** | **Jump performance** | **Strength** | **Conditioning**

Headline

In recent years women's soccer has seen an increase in professionalisation and participation worldwide and the prevalence of injury compared to male counterparts has been well-documented (1). Equally, the relative infancy of structured strength and conditioning support in the women's game has limited the current availability of physical profiling normative data which could facilitate physical benchmarking and monitoring of meaningful change (2).

Aim

The aim of this analysis was to explore the differences in locomotor and neuromuscular performance capabilities of a men's and women's 1st team squad from the same professional football club. Comparative data using contemporary outcome measures, now accessible to many women's squads, may offer a yard-stick to identify which physical qualities have greatest head-way for improvement. Therefore, on the basis of the data presented, a secondary aim of this study was to provide tentative recommendations for targeted physical performance and prophylactic programming.

Methods

Participants

Seventeen professional senior men's squad players (age: 25 ± 4.1 years; height: 182.3 ± 5.1 cm; body mass: 80.1 ± 5.2 kg) and nineteen professional senior women's squad players (age: 23 ± 3.8 years; height: 170.3 ± 4.3 cm; body mass: 63.1 ± 4.2 kg) agreed to take part in the present study. Data were collected in line with the football clubs' daily practices which all conformed to the declaration of Helsinki.

Procedures

All trials were performed during the in-season period (September) and followed a standardised warm-up. To assess maximum aerobic speed (MAS), a 1000m time trial was performed to which all players were previously accustomed to. The methodology and validity of the 1000m time trial (10 x 100m shuttle run) has been outlined previously (3). Maximal sprinting speed (MSS) was assessed during a maximal 40m sprint using GPS technology (Catapult, S7). A countermovement jump (CMJ) and Drop Jump (DJ) were performed on portable force platforms sampling at 1000 Hz (ForceDecks, Vald Performance, Sydney, Australia) with players instructed to "with hands on hips, jump as high as you can, as fast as you can". From the CMJ, two separate metrics were recorded; jump height (flight time) (CMJ Height) and mean eccentric power (during the deceleration phase of the CMJ) (CMJ mean ecc power). Reactive Strength Index (RSI) (jump height/contact time) was recorded from the DJ trials. Finally, posterior chain relative strength (ISO Ham Strength) was assessed via a prone isometric hip extension trial performed using a Nordbord (Vald Performance, Sydney, Australia). Experimentally, once players ankles were secured in the Nordbord hooks (above the lateral malleolus) they were instructed to 'plank' on a 20cm box placed directly in front of the Nordbord with minimal hip and knee flexion (20° flexion) (Figure 1). Players were instructed to focus on hip extension and not knee extension and to "pull up as hard as you can".

Fig. 1. Set-up for Isometric Prone Hip Extension

Statistical analysis

Descriptive statistics are reported as group mean score ± standard deviations (SD). All parameters were compared between squads via standardised differences in the mean (effect size: Cohen's d) with 95% confidence intervals applied. The following criteria were adopted to interpret the magnitude of the change; >0.2-0.6, small; 0.6-1.2, moderate; >1.2-2, large; >2, very large (4). Furthermore, to interpret whether the differences in profiling parameters between squads were practically meaningful, the raw effect was compared against a performance-related practically important change value (Table 1). Finally, to contextualise any observed differences (raw effect), between-day reliability data (coefficient of variation

(CV)) for MAS, MSS, CMJ Height, CMJ Ecc Power, DJ and ISO Ham Strength were 1.6%, 2.0%, 3.4%, 7.6%, 7.5%, 6.6%, respectively (5). Data were analysed using Jamovi (The *jamovi* Project. n. d. jamovi 2.3.21).

Table 1. Practically important change values for profiling parameters derived pragmatically or through internal unpublished case-studies.

Locomotor Parameter	Practically Important Change	Description
MAS	0.2 m/s	Mean difference between centre midfielder and central defender MAS scores*
MSS	0.1 m/s	Represents an advantage of 0.2 metres when evading/denying an opponent following 2 seconds at maximum velocity
CMJ Height	5 cm	Difference between 'Low' (25^{th} percentile) and 'High' (75^{th} percentile) ranking women's players (all positions)**
CMJ Ecc Power	1.5 W.kg	Difference between 'Low' (25^{th} percentile) and 'High' (75^{th} percentile) ranking women's players (all positions)**
Drop Jump	0.31 m/s	Represents the required improvement to reach 30cm jump height with <200ms ground contact compared to 250ms.
ISO Ham Strength	1.9 N.kg	Mean difference in relative strength between 'fast players' (>8.6 m/s max speed) and 'normal speed' players (women) (8-8.5 m/s)**

*Respectively the highest and lowest positional MAS scores (Clancy et al 2023)[6]; **Unpublished case study data from 2 seasons and 49 players. 'Fast players' = 75^{th} percentile +. 'Normal speed' players = 25^{th}-75^{th} percentile.

Results

Box plots showing raw jittered data points for MAS, MSS, CMJ height, CMJ mean eccentric power, Drop Jump and ISO Ham Strength for both squads are presented in Figure 2.

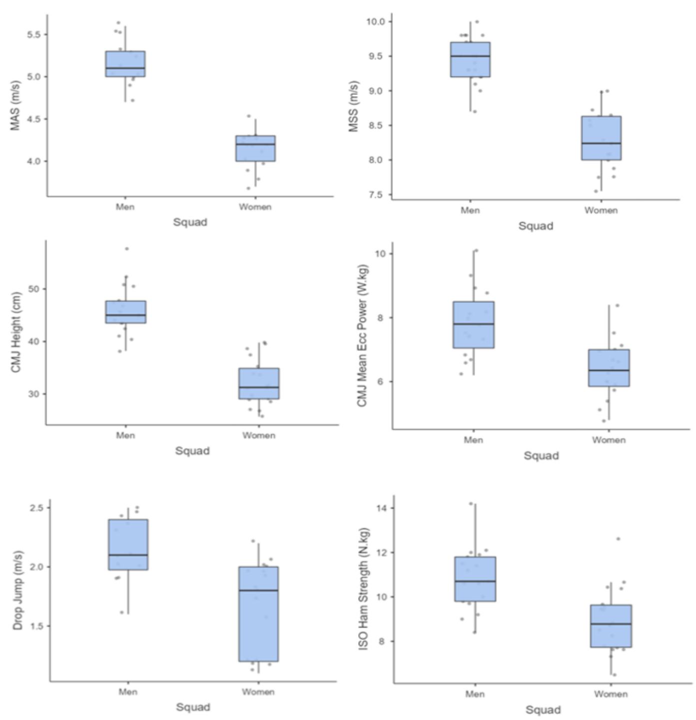

Fig. 2. Box plots showing jittered data points for MAS, MSS, CMJ height, CMJ mean eccentric power, Drop Jump and ISO Ham Strength for men's and women's 1st team squads.

Greater MAS, MSS and CMJ height performance was observed in the men's squad by magnitude's that were *very large* bio-statistically (Cohen's d: 4.3, 3.1, 3.0, respectively) compared to the women's squad and which greatly exceeded the selected thresholds for practical importance for these measures (Table 2).

Greater CMJ mean eccentric power was observed in the men's squad by a magnitude that was *large* bio-statistically (Cohen's *d*: 1.5) compared to the women's squad and which equalled the selected threshold for practical importance for this measure (Table 2).

Greater DJ performance was observed in the men's squad by a magnitude that was *large* bio-statistically (Cohen's *d*: 1.3) compared to the women's squad and which greatly exceeded the selected threshold for practical importance for this measure (Table 2).

Greater ISO Ham Strength was observed in the men's squad by a magnitude that was *large* bio-statistically (Cohen's *d*: 1.3) compared to the women's squad and which was approaching the selected threshold for practical importance (Table 2).

Table 2. Differences in locomotor and neuromuscular performance between men's and women's 1st team squads. Standardised effect size (Cohen's *d*) with qualitative inference and raw effect with practically important change inference.

Physical Profiling Assessment	Effect Size (95% CI)	Qualitative inference (Distribution-based)	Raw Effect	Practical inference (Criteria-based)
MAS	4.3 (2.4, 6.1)	Very Large	1.0 m/s	Greatly exceeds Threshold
MSS	3.1(1.8, 4.3)	Very Large	1.1 m/s	Greatly exceeds threshold
CMJ Height	3(1.8, 4.2)	Very Large	13.8 cm	Greatly exceeds threshold
CMJ Ecc	1.5(0.6, 2.3)	Large	1.5 W.kg	Equals threshold
Drop Jump	1.3(0.4, 2.2)	Large	0.4 m/s	Exceeds threshold
ISO Ham Strength	1.3(0.5, 2.1)	Large	1.8 N.kg	Approaching threshold

Discussion

The main finding of this exploratory analysis was that while the men's squad demonstrated superior performance in all physical profiling assessments, there was variation in the magnitude of effect sizes and practical importance.

Previous research comparing men's and women's professional soccer players has reported larger effect sizes in strength/power related profiling assessments such as jump and sprint performance compared with energy system/locomotor-related profiling (7). Specifically, effect sizes between male and female squads have previously been reported as 1.99 and 1.13 (Hedge's *g*) for CMJ and the Yo-Yo Intermittent Recovery Test Level 1, respectively (7). Physiologically, it is likely that this has been influenced by muscle mass, muscle fibre composition and hormonal advantages (8).

It was therefore interesting to note in the current investigation that among all profiling parameters MAS was found to have the largest gulf between squads. This is perhaps reflective of the relatively short time-trial distance deployed (1000m) to determine MAS and the likely greater demand on anaerobic pathways. Nevertheless, particularly given parity of pitch dimensions and match duration, there is high likelihood of this gulf having a meaningful bearing on match intensity profiles (9) and fatigue status during match-play (10, 11).

Similarly, a *very large* difference in MSS was observed between squads indicating the relative cost of all running velocities during training and competition will be greater for the women's squad. Interestingly, based on the data presented, the anaerobic speed reserve (ASR), representing the difference between maximal aerobic speed (MAS) and maximal sprinting speed (MSS), for men's and women's squads was 4.3 m/s and 4.1 m/s, respectively. This observed ASR difference of 0.2 m/s equates to the difference between the 50^{th} and 25^{th} percentile previously reported in professional men's players (6). This difference is therefore not unsubstantial and given a higher ASR is associated with greater tolerance to high intensity running (12, 13, 14) it may influence the ability within the women's squad to execute a high intensity style of play.

CMJ performance was found to be *very largely* superior in male players re-affirming previous data indicating a greater capacity to produce force relative to body mass during the propulsive phase of the jump (7). Despite both squads receiving identical instruction/queues it is possible different jump strategies adopted between squads also contributed to CMJ performance. Jump strategy, specifically propulsive phase duration affected by countermovement depth, can influence jump height (impulse = force × time) (15). As such, future research may distinguish jump strategy between men's and women's players to examine biomechanical preferences during explosive actions.

Notably, the magnitude of between-squad differences in mean eccentric power during the CMJ was lower than that observed for CMJ height (Cohen's *d*: 1.5 vs. 3.0, respectively) and is perhaps an indication of jump strategy preference. Specifically, relatively higher power output during the eccentric (deceleration) phase of the CMJ among women's players may be driven by a shallower, faster jump (i.e. higher rate of work; work = force × displacement) although this can only be speculated from the present analyses.

It was interesting to note that the observed differences in DJ and ISO Ham Strength between men's and women's players were the lowest, bio-statistically (Cohen's *d*: 1.3, for both) and practically (below practically important threshold; ISO Ham Strength) among all profiling parameters. Interestingly, it has previously been suggested female athletes may have greater capacity to increase relative strength than male athletes (16). Nevertheless, stretch-shortening cycle (SSC) function and neuromuscular performance of the posterior chain musculature have each previously been associated with rehabilitation (17) and prevention of serious ligamentous injuries (18). As such, while the observation of a relatively lower gulf in performance between squads for these parameters may be encouraging for women's players, given the continued evidence of higher injury rates among women's players, practitioners should continue to prioritise these qualities.

Practical implications

- A direct physical profiling comparison using identical testing protocols can be used to understand the limits of male and female player's performance capabilities (Table 2) while assessing strength and conditioning priorities (Table 3).
- From the current data, the observed difference in MAS between squads (1.0 m/s) is 5-fold the selected threshold for practical importance. Conditioning priorities should focus on football and conditioning drills (high metabolic and locomotor demand) for aerobic development (Table 3).
- In the present investigation, a 12% difference in speed performance between men's and women's squads was observed. In comparison, the difference between men's and women's elite sprinters (average speed from respective 60m world records) is 8%. Speculatively, this may be adopted as a target in soccer as it distinguishes male and female athletes at the limits of physiology for this quality. Therefore, in the present study data an increase of 0.3 m/s (to 8.6 m/s and within 8% of men's MSS) may represent a long-term development target for the women's squad.
- Practitioners involved in the jump monitoring of women's players should consider the dynamic between jump height and mean eccentric power with the emphasis on improving both aspects of performance. Specifically, the attainment of improved CMJ height without a corresponding increase/maintenance of eccentric power may reflect a longer and ultimately slower jump strategy.
- In comparison to other profiling parameters, DJ and ISO Ham Strength performance capabilities were found to be relatively closer between squads. As such, the respective group mean values (1.7 m/s and 9 N.kg) may serve as provisional benchmark values for S&C practitioners working in women's soccer.

Table 3. Practical recommendations for women's squad.

Physical Profiling Assessment	Targeted Physiological/Biomotor quality	Training Modality	Performance/ Prophylactic benefit	Priority for Women's Conditioning*
1000 mTT	Aerobic Performance	MAS conditioning (>100% MAS), SSGs (e.g 4×3 mins > 90% max HR)& LSGs (e.g 4×8-10 mins>120 m.min**)	Delayed onset of fatigue	Very high
MSS	Speed	Maximum Speed Exposures/Drills and Sprinting Kinematics	Reduced relative cost of high intensity running	Very High
CMJ Height	Propulsive Impulse	Ballistic/Explosive Strength Training	Improved acceleration capability	Very High
CMJ Ecc	Eccentric Power	Accentuated eccentric loading	Rapid deceleration during SSC	High
Drop Jump	Reactive Strength (SSC)	Fast SSC progressions	Improved max speed capability	High
ISO Ham Strength	Peak Hip Extension Force	Heavy Posterior Chain Strength	Great expression of force during spriniting	High

*Level of priority based on magnitude of difference between squads.
**selected pragmatically as 115% average (90 minutes) match intensity for this squad.
Abbreviations: SSGs (small sides games), LSGs (large sided games).

Limitations

- A limitation of the present study is the small sample size, although this is common in studies of players at a professional level.
- MAS is often assessed over longer distances (≥1200m) in order to prolong the oxidative demands, as such, where alternative protocols are preferred, practitioners should approach the transferability of this data with caution.

References

1. Alahmad TA, Kearney P, Cahalan R. Injury in elite women's soccer: A systematic review. Phys Sportsmed. 2020; 48(3): 259-265.

2. McQuilliam SJ, Clark DR, Erskine RM, Brownlee TE. Mind the gap! A survey comparing current strength training methods used in men's versus women's first team and academy soccer. Sci Med Football. 2022; 6(5): 597-604.

3. Clancy C, Green P, Curnyn S, Donaldson E, Ring N. The concurrent validity and between-session reliability of a 1000m time trial for the assessment of aerobic performance in elite development soccer players. Sports Performance and Science Reports. 2020; 92: sportsperfsci.com.

4. Hopkins W, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sport Ex. 2009; 41(1): 3-12.

5. Duffie K. A case study evaluation of the physical fitness testing battery within a Scottish Premier League Football Club's Academy. 2024. Master by Research. Edinburgh Napier University. January 2024.

6. Clancy C, Owen A, Gilfillan A, Duffie K, Weston M. Comparative analysis of the anaerobic speed reserve in professional soccer: 1st team vs Development team. Sports Performance and Science Reports. 2023; 190: sportsperfsci.com.

7. Schons P, Preissler AAB, Oliveira R, et al. Comparisons and correlations between the anthropometric profile and physical performance or professional female and male soccer players: Individualities that should be considered in training. Int J Sports Sci Coach. 2022; 18(6): https://doi.org/10.1177/17479541221131649.

8. Roberts BM, Nuckols G, Krieger JW. Sex differences in resistance training: A systematic review and meta-analysis. J Strength Cond Res. 2020; 34(5): 1448-1460.

9. Choi JH, Joo CH. Match activity profile of professional female soccer players during a season. J Exerc Rehabil. 2022; 18(5): 324-329.

10. De Ste Croix MBA, El Nagar YO, Iga J, James D, Ayala F. Electromechanical delay of the hamstrings during eccentric muscle actions in males and females: Implications for noncontact ACL injuries. J Electromyogr Kinesiol. 2015;25(6): 901-906.

11. Clancy C, Gleeson N, Mercer T. Match-play, training workloads and sensorimotor and neuromuscular performance of elite young soccer players. Sci J Sport Perf; 1(3): 38-50.

12. Buchheit M, Mendez-Villanueva A. Supramaximal intermittent running performance in relation to age and locomotor profile in highly-trained young soccer players. J Sports Sci. 2013; 31(13): 1402-11.

13. Buchheit M, Simpson BM, Mendez-Villanueva A. Repeated High-Speed Activities during Youth Soccer Games in Relation to Changes in Maximal Sprinting and Aerobic Speeds. Int J Sports Med. 2013; 34: 40-48.

14. Sandford GN, Laursen PB, Buchheit M. Anaerobic Speed/Power Reserve and Sports Performance: Scientific Basis, Current Applications and Future Directions. Sports Med. 2021; 51: 2017-2028.

15. McMahon JJ, Lake JP, Dos'Santos T, Jones PA, Thomasson ML, Comfort P. Countermovement Jump Standards in Rugby League: What is a "Good" Performance? J Str Cond Res. 2022;36(6): 1691-1698..

16. Hubal MJH, Gordish-Dressman PD, Thompson TB, et al. Variability in muscle size and strength gain after unilateral resistance training. Med Sci Sports Exerc. 2005; 37(6): 964-972.

17. Jordan MJ, Morris N, Nimphius S, Aagaard P, Herzog W. Attenuated lower limb stretch-shorten-cycle capacity in ACL injured vs non-injured female alpine ski racers: Not just a matter of between-limb asymmetry. Frontiers in Sport and Active Living. 2022; 4; 853701.

18. Hewitt TE, Stroupe AL, Nance TA, Noyes FR. Plyometric training in female athletes: decreased impact forces and increased hamstring torques. Am J Sports Med. 1996; 24:765-773.