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Section: Original Investigation

Article Title: Physical Preparation Factors That Influence Technical and Physical Match Performance in Professional Australian Football

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"Physical Preparation Factors That Influence Technical and Physical Match Performance in Professional Australian Football" by Ryan S et al.
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Abstract

Objectives: To examine the collective influence of a range of physical preparation elements on selected performance measures during Australian football match-play. ***Design:*** Prospective, longitudinal. ***Methods:*** Data were collected from 34 professional Australian football players from the same club during the 2016 AFL competition season. Match activity profiles, acute (7-day) and chronic (3-week) training load were collected via GPS devices. Training response was measured by well-being questionnaires completed prior to main training session each week. Maximal aerobic running speed (MAS) was estimated by a two-kilometer time-trial conducted during preseason. Coach ratings were collected from the senior coach and four assistants after each match on a 5-point Likert scale. Player ratings were obtained from a commercial statistics provider. Fifteen matches were analyzed. Linear mixed models were constructed to examine the collective influence of training-related factors on four performance measures. ***Results:*** Muscle soreness had a small positive effect (ES: 0.12) on Champion Data rating points. 3-week average HSR distance had a small negative effect (ES: 0.14) on coach ratings MAS had large-to-moderate positive effects (ES: 0.55, 0.47) on relative total and HSR distances. Acute total and chronic average total running distance had small positive (ES: 0.13) and negative (ES: 0.14) effects on relative total and high-speed running (HSR) distance performed during matches, respectively. ***Conclusions:*** MAS should be developed to enhance a player’s running performance during competition. Monitoring of physical preparation data may assist in reducing injury and illness and increasing player availability, but not enhance football performance.

Key Words: physical performance, training, monitoring

Introduction

Wearable microtechnology has enabled coaches and scientists to analyze the physical demands of Australian football training and match-play, facilitating the implementation of training programs to maximize competition performance and minimize injury risk.[1] Given the nature and quantity of training data collected by professional sporting teams,[2] it is likely a number of elements of a player's preparation influence their performance during competition. It is therefore important to routinely quantify the training being completed by players and their response to this stimulus.[1] When training data are interpreted in the context of changes in physical capacity and match performance, coaches and scientists can gain a better understanding of player preparation, enhancing strategies to achieve optimal competition performance.[1]

Previous studies in Australian football and rugby league have demonstrated a link between physical capacities and individual match performance measures, ranging from aerobic and anaerobic capacity, repeat sprint ability and strength measures.[3-5] Indeed, better developed physical capacity has been associated an increased number of disposals in match play,[3] greater match activity[4] and being selected in higher level teams.[5] Other studies have also shown increased training load to associate with improved performance in individual sports such as athletics[6] and endurance running.[7] In contrast, running performance during simulated team sport activity has been shown to decrease following high training loads,[8] while a study in Australian football found a negligible association between acute training load and statistically-derived match performance measures.[9] Moreover, research has established a positive relationship between preseason aerobic capacity and higher competition performance.[3,5,9] Similarly, an association between greater preseason training completion and greater in-season match availability in Australian football competition has been reported.[10] In contrast, few studies have examined relationships between training response through player well-being and subsequent match performance. Collectively, previous research has highlighted the importance of physical preparation on match availability and elements of physical and technical match performance in team sport athletes.

While these studies have expanded current knowledge on optimal approaches for preparing athletes for competition, a common limitation is that they have often only examined selected variables in isolation, without accounting for the contribution of other elements of physical preparation such as training response, training completion and acute and chronic training loads. Given the likely interplay between these factors, further research examining the combined effect of these elements on Australian football match performance measures is warranted.

To date, no research has examined the collective influence of a range of physical preparation elements on match performance of individual players in Australian football. Therefore, the purpose of this study was to examine the combined influence of aerobic fitness, training load and training response on physical output and technical performance during professional Australian football matches.

Methods

Data were collected from 34 professional Australian football players (age: 24.7 ±3.5 y; mass: 88 ±8.1 kg; stature: 1.88 ±0.07 m; playing experience: 68.6 ±68.3 games) from one club (final ladder position: 14/18) during the 2016 Australian Football League (AFL) competition season. Matches analyzed included 4 wins and 11 losses, all of which were played on outdoor grass surfaces in a variety of weather conditions. Players were categorized into the following positions based on where they played the majority of time during each match: small back (n=4), small forward (n=5), midfielder (n=11), ruck (n=3), tall forward (n=6) and tall back (n=5). Informed consent and institutional ethics approval were obtained (HREC: 2016-81E).

Running output was measured in training and matches by 10 Hz Optimeye S5 Global Positioning System units (Catapult Sports, Victoria, Australia). Each unit was assigned to an individual player and worn in a small pouch in their training or match jerseys. After each session or match, devices were removed from the players' jumpers and downloaded using proprietary software (Openfield 1.12.2, Catapult Sports, Melbourne, Australia). The mean horizontal dilution of precision (HDOP) was 0.83 ±0.22 and the mean satellite availability was 11.6 ±1.2 during data collection. 15 matches from the 2016 AFL competition season were analyzed, while matches played at an indoor stadium (n=7) were excluded from the analysis, as GPS data was unable to be collected in this location using the same devices. Data files were then cleaned to ensure only recorded data from time spent on the field and during actual training activities was retained for recording purposes. Following this, the training files for each player were exported and placed into a customized Microsoft Excel spreadsheet (Microsoft, Redmond, USA) for analysis. This provided single figures to represent the total distance covered and total HSR distance (distance covered at a customized speed of >20 $km \cdot h^{-1}$)[11] covered by each player for that particular training session, relative to their time spent within training drills.

Both acute (7-day) and chronic (3-week) running distance for each player was collected throughout the season. These periods were chosen based on their utility in explaining injury likelihood and are reflective of competition and training scheduling in these athletes.[12] Acute training load consisted of the total and HSR running distances completed by each player during the training week prior to a match. A secondary binary measure of acute training load completion was expressed in the form of "yes" or "no" to indicate if that player completed the main training session in the week prior to a match, either in a full or modified capacity A "no" classification was given to a player who completed a rehabilitation session away from the main playing group, or who did not train at all.

Chronic training load consisted of the average weekly total distance and HSR completed by players during the three weeks prior to the week before a match, training and matches included. The percentage of preseason training completed by each player was also obtained to indicate the proportion of all possible training they completed from the commencement of the preseason period to the week prior to the first official competition match of the 2016 AFL season.

Maximal Aerobic Speed (MAS) was measured prior to the start of the season using a two-kilometer run time trial, shown to be a valid test of aerobic fitness in Australian football players used in previous research.[13] Players were instructed to run at maximal effort for two kilometers on a synthetic running track with performance recorded as the time taken for each player to complete the trial. The time was then converted to metres per second, as a measure of MAS.

Individual responses to training demands were measured by well-being questionnaires, which are a practical method of assessing fatigue in team sport athletes.[14] Players completed a short questionnaire on their smartphone or tablet during the morning of the main field training session prior to each competition match, asking them to provide a rating from 1 to 5 (1 representing a low or poor rating and 5 representing a high or good rating, depending on the variable) in relation to their muscle soreness, sleep quality, fatigue level, stress level and current mood state. These responses were then converted to z-scores to indicate the relative change in response for each individual player.[14]

Match technical performance was assessed objectively through Champion Data rating points, provided by a commercial statistics provider (Champion Data, Melbourne, Australia). The rating is computed on the basis of changes in scoreboard equity, which accounts for the contribution of a player's involvement in the play with reference to the location of the involvement, the amount of pressure being applied during that involvement, and also the result of the involvement on the scoreboard.[15]

Subjective measures of match performance were collected in the form of coach ratings of match performance. After each match, all members of the coaching panel (n = 5) provided a subjective consensus rating of each player's performance on a 5 point Likert scale, with 1 representing low performance and 5 representing a high performance. Ratings were made based on coach comparisons of a player's expected performance to their actual performance. Coach ratings have previously been used as a criterion measure of match performance in research in Australian football[16] and has been common practice in the club of this observation group for several years. Whilst this approach possesses face validity, true validation of this approach has not been conducted.

Statistical Analyses

A three-level linear mixed model was used to investigate the influence of training-related factors on match running output, Champion Data rating points and coach ratings of performance during Australian football match-play. The study design located units of analysis (individual player match sample) nested in clusters of units (player), which were nested in larger clusters of clusters (position group). This form of analysis may contain both fixed effects (those that describe the association between a dependent variable and covariates for a population) and random effects (those that are associated with a random factor, generally representing random deviations from relationships described by fixed effects).[17]

Four separate models were constructed to examine the influence of fixed and random effects on (1) Champion Data Rating points, (2) coach ratings of performance, (3) relative total distance and (4) relative HSR. Random factors were included in the model to investigate deviations for players and position groups from the overall fixed intercept and fixed coefficients. The relative total and HSR distances were log transformed prior to analysis to provide differences as a percentage of the mean. Estimate values were log transformed into percentage change values for Model 3 and Model 4, while raw estimates were presented for Model 1 and Model 2 due to the nature of these covariates. The t statistic and degrees of freedom from the mixed model were converted to provide an effect size correlation (r) between each factor and scores on the dependent variable.[18] Effect sizes were derived from r-values to measure the magnitude of change,[19] interpreted as <0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; 0.9–0.99, almost perfect; 1.0, perfect. 95% confidence intervals were also calculated to assess the precision of the estimates.

A ‘step-up’ model construction strategy was used, similar to that used in a previous study.[13] The process began with an “unconditional” model containing only a fixed intercept and level 2 random factors. The model was constructed by adding each single level 1 fixed effect, followed by level 2 fixed effects. The order in which each fixed effect was added to the model was guided by previous research and the investigation team’s own experience in the field. Single fixed effects were only retained if they demonstrated statistical significance ($p < 0.05$) and improved the model information criteria compared to the previous model as determined by a Akaike Information Criterion (AIC) test. Level 1 and 2 fixed effects were also tested for random coefficient effects by comparing a model containing the random effect to that containing the fixed effect for each covariate. An intra-class correlation coefficient (ICC) was used to determine the similarity of observed responses within individual player clusters. All statistical analyses were conducted using the lme4 and psychometric packages in R statistical software (*R.3.1.0, R Foundation for Statistical Computing*).[20]

Results

For all four models, the construction process was optimized by including random intercept effects, demonstrating that there was statistically significant variance in mean relative total and HSR distances, Champion Data rating points and coach ratings of performance between individual players nested in positions. Muscle soreness had a small positive effect on Champion Data rating points, while 3-week average HSR distance had a small negative effect on coach ratings of performance. Level 2 covariate player MAS had a moderate positive effect on relative HSR and a large positive effect on relative total distance. Level one covariate 3-week average total distance had a small negative effect on relative HSR, while 7-day total distance had a small negative effect on relative total distance. The effects of these variables on performance measures are quantified on the basis that all other variables remain constant.

The random intercepts for the four models were 8.3 Champion Data rating points, 1.8 coach rating points, 123.1 $m{\cdot}min^{-1}$ of total distance and 9.3 $m{\cdot}min^{-1}$ of HSR, respectively. The ICC for individual match samples within each player was 0.28 for Champion Data rating, 0.20 for coach ratings of performance, 0.58 for relative total distance and 0.64 for relative HSR. There was a random coefficient effect for 3-week average HSR distance in model 2 (coach ratings of performance), suggesting that this effect varied for all individuals. There were no random coefficient effects for the other 3 models, indicating that these effects were consistent across all individuals.

Discussion

This study investigated the collective influence of a variety of individual and training-related variables on subjective and objective measures of performance in professional Australian football match-play. The main findings were that higher muscle soreness prior to the main training session before a match had a positive relationship with Champion Data rating points obtained during that match, while 3-week average HSR had a negative relationship with coach ratings of performance. Greater 7-day total running distance and lower 3-week average total running distance reduced relative total distance and relative HSR distance performed during a match respectively. Player fitness positively associated with relative total and HSR distances performed during matches. Preseason training completion, 7-day training completion, fatigue, perceived sleep quality, mood, total well-being and 7-day HSR distance showed no significant association with any performance measure. These findings may assist in the physical preparation of players for competition matches and further contextualize training data typically collected by sport scientists of professional Australian football teams.

The current study found players who reported greater muscle soreness prior to a match received higher Champion Data rating points in that match. These observations contradict other research in Australian football and rugby league that have reported a detrimental effect of neuromuscular fatigue on number of disposals and match running output.[21,22] Despite the methodological differences in assessing neuromuscular fatigue between the current study and previous research, these results provide insight into the influence of various forms of fatigue on subsequent match performance. Additionally, a limitation of our study was the collection of well-being responses prior to the main training session of the week, which was often three to four days before a match, potentially diluting the influence of these responses on performance later in the week. Other research in Australian football has identified a weak association between well-being responses and match running output[14] and a poorer integrative score of well-being to associate with lower running output during training.[23] Notably, no association was identified between any of the other well-being measures and match performance in this study. While these metrics may be useful for guiding the training process during preparatory periods, they do not appear to influence match performance. Taken together, the differences between these findings suggest that well-being responses collected prior to training may not be indicative of subsequent physical or technical performance during the following match. While the usefulness of well-being responses to monitor a player's response to training has been established,[24] its relationship with match performance measures remains unclear. Future research may address this limitation by collecting pre-game well-being measures closer to a match and assessing their relationship with subsequent match performance.

The present study was the first to examine the influence of chronic training load on professional Australian football performance. Three-week average HSR distance was associated with reduced coach ratings of performance for a match, but no association was identified between 3-week average total or HSR distances and Champion Data rating points. Our results suggest that coach ratings of performance assess different aspects of match performance to Champion Data rating points, in agreement with a previous study in professional Australian football that reported match running performance and Champion Data rank to only account for 42.2% of the variance in coach ratings of performance.[16] It is possible that greater 3-week average HSR distance induced a level of chronic fatigue in players, reducing the quality of their performance as viewed by their coaches. . In support of our finding, a previous study reported a negative effect of neuromuscular fatigue on coach votes awarded during AFL matches,[21] suggesting that fatigued players tend to produce poorer performance during a match from the perspective of their coaches. Future research may examine the relationship between coach ratings of performance and other match performance measures to fully explore this method of performance assessment.

A further finding of the present study was that higher 7-day total running distance and lower 3-week average total running distance reduced the relative total distance and relative HSR distances performed during matches respectively. This complements other research in rugby athletes that reported high acute training loads to reduce sprint velocity and total distance performed during simulated match activity.[8] However, these observations are in contrast to another study in professional Australian football that reported increased total and HSR distances were performed during training drills following increases in training load.[25] This finding suggests that players can maintain and in some cases, perform greater running distances following increased acute training loads.. The lack of agreement among these studies could be due to different season phases being examined, in addition to the type of match-play used to represent match running output. However, the reduction in relative HSR distance performed during matches following lower 3-week average total distance identified in the current study emphasizes the importance of chronic training load completion to positively influence match running output. Overall, these results indicate that a balance must be achieved between prescribing running load to elicit positive training adaptations in preparing a player for optimal competition performance, but not so much to have a detrimental effect on match running output.[1] Indeed, inverse relationships between running output and other performance measures exist,[16,26] however in practice, this output is often used as a measure of at least part of a player's overall performance. It is therefore necessary to consider a range of contextual factors that influence match running output when used as a basis for performance assessment.[13] Future research may examine other modalities of training not included in this study – such as strength training – and their associations with subsequent match running performance to further explore this relationship.

The influence of aerobic fitness on running performance in team sports is well established.[3,13] Our results showed players with greater MAS performed more relative total distance and HSR distances during matches, complementing the findings of research from other team sports.[3,4] This is likely due to players with such physical capacity being placed in positions where greater running volumes are required, such as midfield.[27] While we observed associations between MAS and match activity profiles, no relationships were identified with other performance measures. This finding is surprising, given the relationship between aerobic fitness and objective football measures such as number of disposals and statistically derived impact scores that has been reported elsewhere.[3,9] However, the relationship between physical output and technical performance is certainly mediated by a range of contextual factors.[13,28,29] Additionally, the Yo-Yo Intermittent Running test or the 40-metre repeat sprint test are arguably more appropriate running tests for Australian footballers than MAS.[3,5]

A notable observation was the lack of association between preseason training completion with any performance measures in this study, contradicting previous reports of association between preseason fitness measures and both running performance and direct game involvements during in Australian football match-play.[3,30] While the proportion of total training sessions completed is not reflective of distances covered or quality of training, our finding suggests that relationships between preseason training completion and subsequent performance measures are mediated by other factors not accounted for in this study, such as cumulative preseason training completion and different training modalities specific to a player's individualized training program. These findings also indicate that preseason training completion is a blunt measurement of physical preparation for competition and requires detailed analysis of its content before an association with match performance can be established. Indeed, the nature of the training and the skills required to be completed within specific drills should be considered, rather than the nominal completion of planned sessions to further explore this relationship.

While this study is the first to examine the collective influence of a range of physical preparation factors on match performance measures in Australian football, caution should be taken when applying the present findings to other team sports, as they may reflect the individual characteristics and team tactics of the observation group. Moreover, the small sample size of 34 players across 15 games also limits the generalizability of our findings. Lastly, non-linear statistical approaches to analyzing these data may elucidate associations not identified in this study.

Conclusion

This study investigated the effects of training related and individual characteristics on objective and subjective performance measures in Australian football match-play. Our findings highlight the multi-faceted nature of preparing players for competition, and emphasize the need to interpret physical preparation data in the context of subsequent match performance. Technical performance is vital to successful match outcomes, however the variables typically collected by sport scientists such as those examined in this study appear to have weak associations with match performance measures. Future studies should endeavor to examine alternative preparatory measures to gauge technical and tactical preparedness of players for competition match-play.

Practical Applications

- Chronic HSR distances completed during training may induce a level of fatigue that influences a player's match performance as viewed by their coaches.
- To increase running output during competition, coaches and scientists should endeavor to develop a high level of aerobic fitness in their players during the preseason period.
- Analysis and interpretation of monitoring data can assist in reducing injury and illness and increasing player availability through alteration of physical preparation programs, however it does not necessarily facilitate enhanced football performance.

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Table 1: Covariates included in model specification.

Level of Data		Factors	Type	Classification
Level 3	**Cluster of clusters (random factor)**	*Position*		
Level 2	**Cluster of units (random factor)**	*Player*		
	Covariate	Fitness Score	Continuous	Maximal Aerobic Speed (m·s[1])
		Preseason Training Completion	Discrete	Percentage of training completed
Level 1	**Unit of analysis**	*Individual match sample*		
	Dependent variable	Relative total distance (Model 1)	Continuous	$m \cdot min^{-1}$
		Relative high-speed distance (Model 2)	Continuous	$m \cdot min^{-1}$
		Champion Data rating points (Model 3)	Continuous	Points for that player
		Coach rating of performance (Model 4)	Interval	Rating for that player
	Covariates	Training in week	Dummy variable	0 = No, 1 = Yes
		7 day total distance	Continuous	metres
		7 day high-speed distance	Continuous	metres
		3 week average total distance	Continuous	metres
		3 week average high-speed distance	Continuous	metres
		Muscle soreness	Continuous	Z score of response for that player
		Fatigue	Continuous	Z score of response for that player
		Stress	Continuous	Z score of response for that player
		Sleep	Continuous	Z score of response for that player
		Mood	Continuous	Z score of response for that player
		Total wellness	Continuous	Z score of total response for that player

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Table 2: Raw effects of covariates on Champion Data rating points in professional Australian Football (95% CI).

	Champion Data rating points (Model 1)				
	Coefficient	95% CI	df	t value	Effect Size
Fixed Effects					
Intercept ($m \cdot min^{-1}$)†	8.3	7.4, 9.2	33.3	15.0	
Muscle soreness	-0.4	-0.7, -0.07	283	-2.0	0.12 [0.01, 0.23]

CI: confidence interval; df: degrees of freedom; †Exponential of intercept.

Table 3: Raw effects of covariates on Coach ratings of performance in professional Australian Football (95% CI).

	Coach ratings of performance (Model 2)				
	Coefficient	95% CI	df	t value	Effect Size
Fixed Effects					
Intercept ($m \cdot min^{-1}$)†	1.8	1.4, 2.2	155.6	27.6	
3 week average high-speed distance	-0.00037	-0.00061, -0.00013	298.3	-2.5	0.14 [0.03, 0.25]

CI: confidence interval; df: degrees of freedom; †Exponential of intercept.

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Table 4: Percentage effects of covariates on log transformed relative total running distance in professional Australian Football (95% CI).

	Total distance (Model 3)				
	Coefficient	95% CI	df	t value	Effect Size
Fixed Effects					
Intercept (m·min^{-1})†	123.1	118.6, 127.8	39.1	212.2	
7 day total distance	0.000219	0.0000576, 0.000379	281.9	2.2	0.13 [0.02, 0.24]
Player fitness	0.64	0.36, 0.92	33.2	3.7	0.55 [0.47, 0.62]

CI: confidence interval; df: degrees of freedom; †Exponential of intercept.

Table 5: Percentage effects of covariates on log transformed relative high-speed running distance in professional Australian Football (95% CI).

	High-speed running distance (Model 4)				
	Coefficient	95% CI	df	t value	Effect Size
Fixed Effects					
Intercept (m·min^{-1})†	9.3	7.3, 11.7	65.9	15.4	
3 week average total distance	-0.001	-0.0018, -0004	290.6	-2.4	0.14 [0.03, 0.25]
Player fitness	3.1	1.5, 4.6	35.2	3.2	0.47 [0.38, 0.55]

CI: confidence interval; df: degrees of freedom; †Exponential of intercept.