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Title Page:

Efficacy of subjective ratings of wellness in monitoring adaptive responses to training and competition in elite Australian football

Running head: Monitoring adaptive responses to training and competition

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Efficacy of subjective ratings of wellness in monitoring adaptive responses to training and competition in elite Australian football

Abstract

Perceptions of wellness are often used by athletes and coaches to assess adaptive responses to training and guide performance management. The purpose of this research was to evaluate the efficacy of using training diary ratings of wellness to assess how players were coping with the demands of elite level Australian football over a competitive season. Twenty seven players from an Australian Football League club completed ratings for nine variables (fatigue, general muscle, hamstring, quadriceps, pain/stiffness, power, sleep quality, stress, wellbeing). Players subjectively rated each variable as they arrived at the training or competition venue on a 1-5 visual analog scale, with 1 representing the positive end of the continuum. A total of 2,583 questionnaires were analysed from completions on 183 days throughout the season (92 ± 24 per player, 103 ± 20 per week; mean \pm SD). Descriptive statistics and multi-level modeling were used to understand how player ratings of wellness varied over the season and during the week leading into game day and whether selected player characteristics moderated these relationships. Results indicate that subjective ratings of physical and psychological wellness are sensitive to weekly training manipulations (i.e., improve steadily throughout the week to a game day low), to periods of unloading during the season (i.e., a week of no competition) and to individual player characteristics (e.g., physical wellness after a game was poorer in players with high maximum speed). It is concluded that training diaries incorporating athlete ratings of wellness provide a useful tool for coaches and practitioners to monitor player responses to the rigorous demands of training, competition and life as a professional athlete.

Key words: performance; training; muscle fatigue; recovery; athlete monitoring; team sports

Introduction

Changes in mood and affective states have frequently been described as consistent, sensitive and early markers of overreaching and overtraining in competitive athletes ¹⁻². At least two sport specific tools are available in the literature that attempt to assess an athlete's ability to cope with the physical demands of training and competition and the daily life demands of performance sport ³⁻⁴, while several other research groups ⁵⁻⁷ have chosen to use and recommend a combination of available psychometric tools and checklists in their training and performance monitoring regimes.

Monitoring athlete wellness and adaptive responses to training and competition is also of interest to coaches and practitioners, yet in their performance driven environment they are generally challenged by the practicalities of incorporating these comprehensive research tools into busy training schedules where both compliance ("athletes hate paperwork" ⁸) and the extent of data collection and analysis may be difficult. As such, practitioners have been encouraged to incorporate the concepts underpinning these psychometric tools into some form of training diary ^{2, 9-10}. The literature contains little in terms of the efficacy of these applied practices, particularly in team sport athletes where training and competition loads are relatively consistent over extended periods of time and the emphasis is on the routine management of fatigue and recovery to perform on a weekly basis.

The purpose of this research therefore was to evaluate the efficacy of using subjective ratings of wellness to assess how players were coping with the demands of elite level Australian football over a competitive season. Australian football is a physically demanding team field sport which includes body contact, repeated high intensity efforts and running distances of approximately 12 km per game at the elite-level ¹¹. Of particular interest was the responsiveness of ratings of wellness during the training week and to periods of unloading during the season and whether these self-reported ratings were influenced by individual player characteristics.

Methods

Subjects

The analysis was based on data provided by 27 senior professional players (mean \pm SD [range]; age 24.4 ± 2.9 years [19 – 30]; height 187.4 ± 7.0 cm [175 – 202]; weight 89.9 ± 8.1 kg [77 – 108]; playing experience 96.6 ± 58.7 senior games [9 – 213]) from the same club during the 2007 Australian Football League (AFL) season. Methods for the study were approved by the club and a university ethics committee.

Player speed over 40 m (31.6 ± 1.5 km/h [29 – 35]) and 3 km time-trial running endurance (619.5 ± 39.6 s [558 – 698]) were assessed during mid-January in the pre-competition period. Tests were conducted on a well-maintained grass surface, after an appropriate warm-up. Speed was assessed with timing gates (Swift Technology, Lismore NSW) to one hundredth of a second and then converted to km/h. The 3 km time-trial took place around an oval 460 m in circumference, measured with a calibrated trundle wheel, with markers placed every 20 m. The typical error for these tests in this playing group, expressed as a coefficient of variation, was 1.4% for the 40 m sprint ($n = 22$) and 1.1% for the 3 km time trial ($n = 19$).

Training and Competition

For this club, the season consisted of 22 home and away games (weeks 1 – 22), three finals games (weeks 24, 26, 27) and two weeks in which no game was played (weeks 13, 25). Data leading into a week where no game was played were not assessed, while data immediately post this week and leading into the next game were included. Weeks 7, 14, 22 and 26 represented periods of reduced training within the periodised training program. Games were played on a weekly basis, with some variation in the number of days between games depending on when the game was played on the weekend (i.e., Friday, Saturday or Sunday). A consistent pattern of training was prescribed each week with scheduling determined by the day of the upcoming game, allowing for comparisons of data on any given day possible. The days immediately post game focused on recovery and modified training; the main training session of the week was scheduled three days prior to the game (Day 3: 72 ± 8 min

training time excluding breaks, range 55 – 85 min); light skill and tactical sessions preceded the game (e.g., Day 1: 39 ± 3 min, range 33 – 46 min). The weekly training schedule, including the typical prescribed physical load as a percentage of total weekly load (estimate based on routine GPS, heart rate and rating of perceived exertion data), was as follows: Day 6 - recovery; Day 5 - skills (2%) and weights (3%); Day 4 - off; Day 3 - skills (12%) and weights (10%); Day 2 - skills (4%); Day 1 - skills (4%); Day 0 - game (65%).

Wellness

The players completed ratings for nine wellness items, six of which were physical in nature (fatigue, general muscle, hamstring strain, quadriceps strain, pain/stiffness, power) and three psychological or lifestyle related (sleep quality, stress, wellbeing). A composite wellness scale was calculated based on the mean of these nine items, which demonstrated good internal reliability (Cronbach's $\alpha = 0.87$ based on 2,583 samples; mean inter-item correlation = 0.46, range: 0.25 – 0.76).

Players subjectively rated each item as they arrived at the training or competition venue on a computer screen displaying a visual analog Likert scale ranging from 1 (feeling as good as possible) to 5 (feeling as bad as possible). The players were familiar with the rating system having completed the process over the pre-season period and been instructed in its use by the senior sport scientist at the club. Data was entered before any scheduled activity, usually in private and at a consistent time in the morning on similar days, with the exception of late afternoon for night matches. Data were recorded directly into sport specific software (Athletrak Ver. 8.06, Athlete Logic, Cheshire, U.K.), and for the purposes of this study, exported at the conclusion of the season for analysis. During the season the data was considered on a daily and weekly basis by senior sport science and conditioning staff to assist with individual player management and training prescription.

Performance

Relationships with weekly playing performance, a recommended variable of interest within the overtraining literature¹² and a primary objective of each individual player, were also assessed.

Each player's performance during competition was recorded as a single performance score derived from 33 individual game statistics that incorporated all aspects of play (i.e., offensive, defensive and stoppages) provided by two AFL approved companies (Champion Data, Victoria: <http://www.championdata.com.au/>; ProWess Sports, Victoria: <http://www.prowess.com.au/>). In a procedure similar to that used by Richmond et al ¹³ individual statistics were weighted for importance by the coaching staff using a confidential formula agreed at the beginning of the season. The playing performance score was expressed in arbitrary units (au) and calculated on a weekly basis for each player after every game.

Data analysis

Behavioural data, such as that collected over a season in this applied setting, can be hierarchical and commonly have a nested structure as measurement occasions and the number of repeated observations on each individual are not identical ¹⁴. Multi-level linear modeling techniques have been developed to appropriately deal with data structures such as these, with each sub-model representing the structural relations and residual variability at that level. In the present study, multi-level models were used (HLM Ver. 6, Scientific Software International Inc., Lincolnwood, Illinois) in order to test the significance of week and day of the week effects on wellness, and assess for moderating effects of player characteristics on these relationships. This approach fits a model for each player from repeated observations over time (level 1 predictors) and then models each coefficient in these models as a random effect allowing for differences in player characteristics (level 2 predictors). Characteristics typically used to describe a player were used as level 2 predictors in the analysis: age, height, weight, speed, running endurance, playing experience.

Data are presented as mean \pm standard deviation (SD), with statistical significance set at $p < 0.05$. To analyse trends across the week, data for each similar day for each player were used (e.g., all ratings for day 6, day 5, etc.). To analyse trends across the season, the mean and rating variability for each player for each week were used (e.g., the mean and SD of daily ratings for week 1, week 2, etc.). Correlations

between the game performance score and wellness scores (mean and SD for the week) were examined to determine what wellness items were likely predictors of performance.

Results

Wellness

In total 2,583 questionnaires were analysed from completions on 183 days throughout the season. This represented a mean total of 92 ± 24 completions per player for the season (range 31 – 132; compliance 70%), 3.8 ± 0.7 completions per player for each week and 103 ± 20 completions per week for the entire squad.

Table 1 summarizes significant effects for the absolute player wellness data and variation in player ratings over the week and season. Perceptions of wellness in all nine items typically had low values (the constant term in Table 1; lower scores being preferable on the 1-5 scale) suggesting players generally coped well with the demands of elite AFL football. Pain/stiffness and sleep quality had the highest average scores (over the entire season) with quadriceps strain, stress and wellbeing having the lowest scores.

The slope for days to game is always significant (Table 1a, Figure 1), highlighting the improvement in all wellness items as game day approaches. However the coefficient for the slope is moderated in several items by maximum speed, indicating that faster players have significantly higher (worse) ratings for muscle strain, hamstring strain, quadriceps strain and power following a game. Sleep quality is more adversely affected following a game in older players.

Figure 2 presents data over the season for the composite wellness scale with individual ratings for fatigue, muscle strain and wellbeing significantly declining over the course of the season (Table 1a). Several items were significantly lower immediately post a week of no competition in week 14 (fatigue, hamstring strain, quadriceps strain, power, sleep quality, composite wellness) and week 26 (fatigue, pain/stiffness, power).

The effect of weeks on several wellness items is moderated by the individual characteristics of playing experience and maximum speed. Ratings of fatigue and the composite wellness scale improved more so as the season progressed for players with higher maximum speed. For players with greater game experience (total AFL games played) ratings of quadriceps strain and power improved to a greater extent over the season while wellbeing deteriorated.

The slopes for data across the week indicate that variability between players declines significantly as game day approaches. The greatest decrease in variability (higher slope coefficient in Table 1b) occurs for quadriceps strain, fatigue and power, with stress and wellbeing showing the smallest decrease. Variability declines significantly over the season for all variables except pain/stiffness.

Performance

Analysis of the relationships between wellness and performance formed the second part of this investigation. A total of 359 individual playing performances from 25 competitive games over the season were considered. Playing performance was derived from individual game statistics and was measured in arbitrary units (113.1 ± 51.8 au, range 8 – 279).

A few significant but very weak negative correlations with performance were observed for general muscle ($r = -0.105$, $p = 0.042$) and hamstring strain ($r = -0.110$, $p = 0.033$) and for the standard deviation of quadriceps strain ($r = -0.178$, $p = 0.001$) and hamstring strain ($r = -0.121$, $p = 0.022$). Stress levels over the week were positively correlated with performance ($r = 0.216$, $p < 0.001$).

Discussion

The purpose of this investigation was to assess the efficacy of player self-reported ratings using a customized daily monitoring questionnaire over an entire season in a professional Australian football team. Trends over the season and within the training week were evident, while individual player characteristics such as age, playing experience and maximum speed moderated responses for a number

of wellness items. These results suggest that player self-ratings are sensitive to daily and weekly variations in recovery status and support the use of player self-monitoring within a professional team sport environment.

Changes in neuromuscular performance and endocrine status have been observed up to 72 hours post an elite Australian football game, with mean power and flight to contraction time ratio in a single countermovement jump decreased and cortisol substantially elevated 24 hours post game before returning to pre-game levels around 72 – 96 hours post game ¹⁵. Following a soccer match exercise performance (sprint and leg muscle strength) and markers of oxidative stress and muscle damage remain elevated at 48 – 72 hours ¹⁶. Similar fatigue responses and the pattern of change over the training week are evident in players' perception of physical and psychological wellness in the present study. Poorer ratings of wellness on days 6, 5 and 4 suggest considerable fatigue from the game which by day 3 was reasonably attenuated to allow participation in the main training session for the week. Further improvements leading into a game day low suggest players perceived themselves to have recovered and were ready for the upcoming game. In monitoring a group of professional rugby union players, Nicholls et al ⁷ also found that more stressors were worse than normal the day after a game than on game day, with ratings on training days typically worse than on both rest days and games days.

An important finding in this study is that players with higher maximum speed report worse ratings for power, muscle strain, hamstring strain and quadriceps strain in the days following a game and consequently take longer to recover to baseline levels. Exercise induced muscle damage is influenced by a variety of factors including exercise intensity, the number and velocity of contractions during exercise, work performed, exercised muscle length and individual differences in fibre type composition and muscle architecture ¹⁷⁻¹⁸. Faster players may therefore be more susceptible to muscle damage due to factors related to how they play the game (e.g., greater speeds, rapid changes in direction and acceleration/deceleration, increased ground impact when running and on body contact) or to inherent factors related to muscle structure and composition. While these and other mechanisms

may be involved, this is clearly speculative and warrants further investigation, particularly in collision based running sports. Measurements of physical load in the actual game along with specific markers of fatigue and muscle damage are required to better assess the potential relationship between speed and recovery.

Changes in ratings of sleep quality following a game and in the days immediately after are consistent with observations in athletes in heavy training¹⁹, after prolonged vigorous exercise²⁰, and with suggested links with increases in pro-inflammatory cytokines²¹. Support for further moderation of these changes in older athletes in the present study within such a narrow age range (i.e., 19-30 years) is not available although sleep quality is known to deteriorate with age²². Older players also report lower average ratings for quadriceps strain and power while those with greater game experience report improvement in these two variables across the season. Explanations for these findings are unclear.

The significant improvements in ratings of wellness following a single week of reduced physical load (i.e., no game and reduced training time in weeks 14 and 26) further demonstrates the sensitivity of player self-reports to daily changes in training and competition circumstances. Coutts and colleagues have recently demonstrated physiological and performance improvements²³ along with psychological improvements²⁴ following a short 7 day training taper in semi-professional rugby players. The current study adds to this work in that it provides a daily time course related to changes in perceived wellness in response to both the routine reduction in training leading into each weekly game and the more marked reduction in training and football involvement associated with a week of no competition. The scheduling of a bye week (or a period of unloading) in the middle of the competitive season clearly has physical and psychological benefits.

Improvements in ratings of fatigue, muscle strain and wellbeing were observed over the course of the season as were decreases in rating variability. These improvements may be a result of a well managed and administered training program, including effective recovery strategies and training load manipulations²⁵. They may also reflect subtle adaptive improvements in players' ability to cope with

the demands of training and competition, although improvements in routine measures of fitness are typically not observed beyond the preseason ²⁶. From a psychological perspective, as the season progresses, greater certainty likely exists for players in terms of their position within the team and their ability to endure the season. In support of this notion, the greatest decline in rating variability over the season was observed for the items of stress and wellbeing. This club had a particularly successful year (AFL Premiers) such that improvements over the season may simply reflect this success. As such, future research may consider the influence of team and individual success on player perceptions of wellness.

The relationship between individual performance and ratings of wellness in this playing group is generally non-existent although a few very weak significant correlations with performance exist for some physical wellness items. Negative correlations with performance for general muscle and hamstring strain and for variation in ratings over the course of the week in quadriceps and hamstring strain suggest that performance is negatively impacted in players who report higher physical stress in these variables in any given week. While these correlations may only account for 1-3% of the variance in performance, winning and losing in professional sport is often determined by small margins and any negative impact on performance is considered important.

This study presents player self-ratings of wellness collected over an entire season in professional AFL footballers. The data is extensive (2583 questionnaires collected on 183 training or competition days) and represents a good level of compliance. Other more detailed psychometric scales have been used within sport to evaluate athlete responses, yet these have typically been administered on a small number of occasions or over a relatively short period of time ²⁷⁻²⁹. This study demonstrates that player self-monitoring through the use of a typical training diary, which includes a number of carefully selected physical and psychological items, can provide valuable insight into the adaptive responses of athletes when training and competing. These practical tools have an advantage in a performance driven environment in that they are brief and easy to administer on a regular, even daily basis, yet may

lack the detail and established validity that other stress and mood inventories used within sport research provide.

Practical Implications

- Subjective ratings of wellness appear sensitive to changes in load and individual circumstances and provide a useful tool to monitor adaptive responses to the rigorous demands of training, competition and life as a professional athlete.
- Competition breaks within the season have physical and psychological benefits such that team sports with long competitive seasons should look for opportunities to periodically unload their players.

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Table 1a: Multi-level models for the nine wellness items and the composite wellness scale.

Wellness Items	Constant	Slope: Days to Game	Slope: Weeks
Fatigue	1.45	.063***	-.004* -.003(Speed)*
Muscle Strain	1.52	.072*** +.011(Speed)***	-.004 *
Hamstring Strain	1.46	.056*** +.008(Speed)***	.002
Quadriceps Strain	1.29 -.02(Age)*	.037*** +.010(Speed)**	-.002 -.000055(Games)**
Pain/stiffness	1.57	.089***	-.002
Power	1.39 -.03(Age)*	.060*** +.015(Speed)**	-.002 -.000038(Games)*
Sleep Quality	1.58	.057*** +.007(Age)*	-.004
Stress	1.32	.017*	-.005
Wellbeing	1.28	.022***	-.004** +.000070(Games)**
Wellness (composite)	1.43	.052***	-.003 -.002(Speed)*

Table 1b: Multi-level models for variability (log of wellness variance) in the nine wellness items and the composite wellness scale.

Fatigue	-2.44	.239***	-.024***
Muscle strain	-2.14	.174***	-.025***
Hamstring strain	-2.00	.153***	-.008*
Quadriceps strain	-2.75	.294***	-.027***
Pain/stiffness	-1.92	.191***	-.001
Power	-2.59	.244***	-.016***
Sleep quality	-1.31	.119***	-.020***
Stress	-2.17	.042**	-.063***
Wellbeing	-2.62	.039***	-.048***
Wellness (composite)	-3.17	.174***	-.031***

*p <0.05, **p<0.01, *** p<0.001

Slope coefficients relate to wellness data during the week (Days to Game) and over the season (Weeks).

Player characteristics used as level 2 predictors in the analysis: Age, height, weight, 6 minute running endurance, maximum speed (Speed), playing experience (Games).

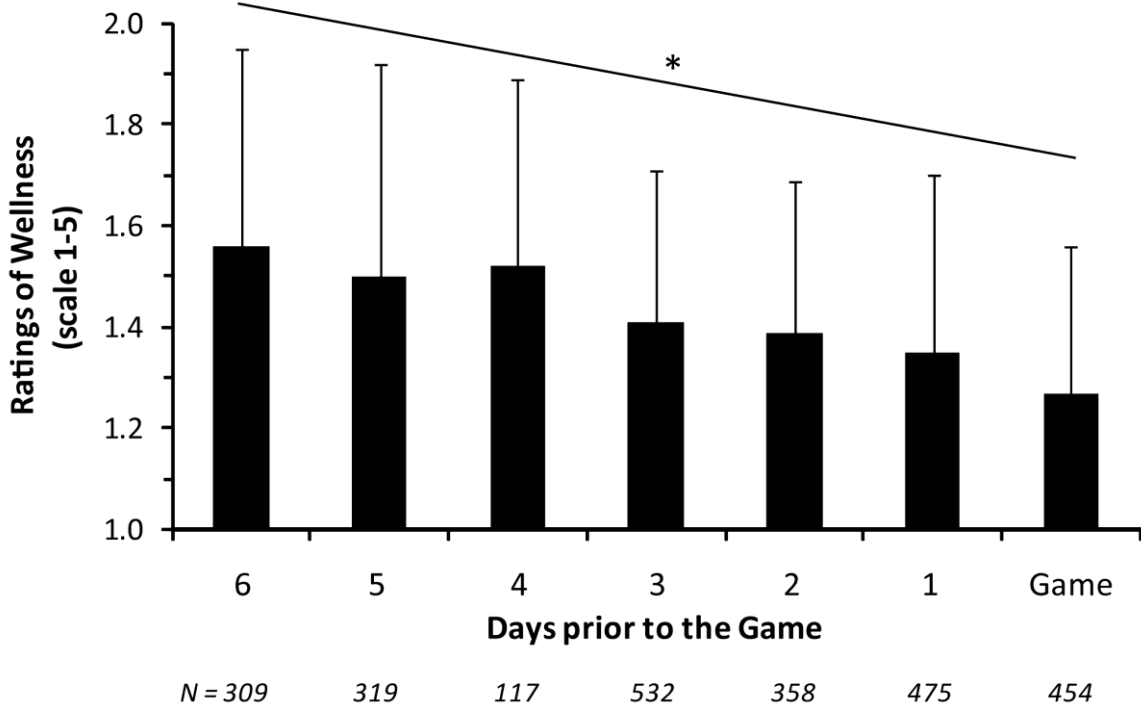


Figure 1:

Mean rating (\pm SD) in the composite wellness scale over the course of the week.

Data presented for 27 players, with differences in number of completions (N) per day related to some individual variation in player training schedules and questionnaire compliance.

* Significant slope coefficient across the week ($p < 0.001$)

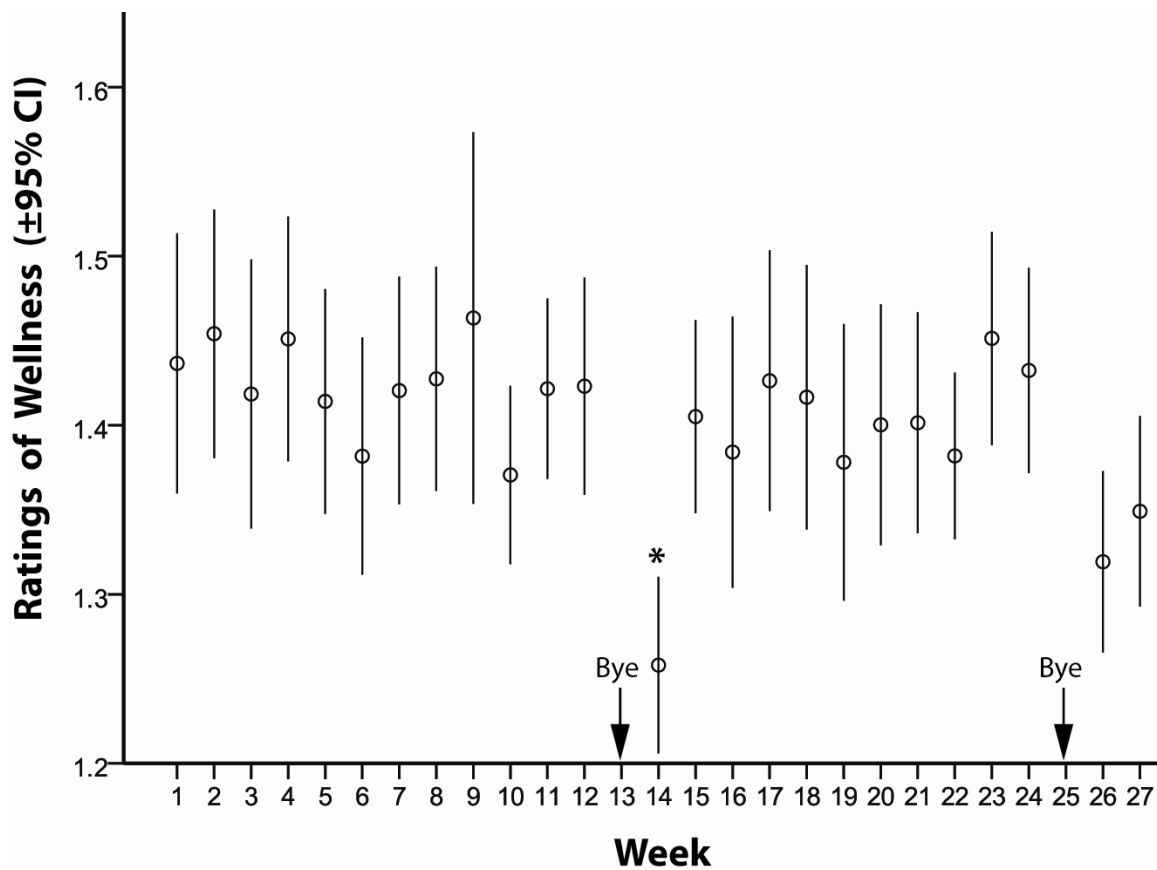


Figure 2:

Mean and 95% confidence intervals for the composite wellness scale over the season.

Weeks 13 and 25 (data not presented) represent a week of no competition (Bye).

*Significantly different from the week before ($p < 0.05$).