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Does the FIFA World Cup's Congested Fixture Program Affect Players' Performance?

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Abstract

Background: The tournament design of any FIFA World Cup™ is characterized with a high amount of games within a short period of time with limited recovery periods. This study aimed to investigate alterations in match activity and fatigue patterns of players from top ranked teams during the 2014 FIFA World Cup in Brazil.
Methods: The performance data from the final four ranked teams were recorded from the official game statistics of the federation internationale de football association. Inclusion criteria were: a) played during the seven matches, and b) took part in at least 85% of the total playing time of its respective team.
Results: Seventeen players fulfilled the criteria (eight defenders, five midfielders and four attackers). Average exposure of the selected players was 97.4% ± 4.1% (range 86% - 100%) of the tournament regular official playing time. Total distance covered was lower ($P < 0.05$) in the fourth (round of 16) and fifth (quarterfinals) game than in the first and the sixth (semi-finals). Moreover, high-intensity running was lower in game five than one ($P < 0.05$), six ($P < 0.01$) and seven (finals and 3th - 4th place; $P < 0.05$). Additionally, players performed a lower number of sprints in game five than in game seven ($P < 0.05$). An intensity composite score revealed that game five was less intense ($P < 0.05$) than game one, six and seven. Additionally, substantially small decrement (Effect size = 0.4) in the number of sprints between post-peak match (subsequent game to peak-match) and average-five matches was observed.
Conclusions: The analyses suggest that there wasn't a general decline in player's match activity during the 2014 FIFA World-cup in Brazil in a congested schedule.

Keywords: Performance Analysis, Time-Motion, Fatigue, Pacing

1. Background

The tournament design of any FIFA World Cup™ is characterized with a high amount of games within a short period of time with limited recovery periods. These periods are not only devoted to recovery but also to preparing the next game's tactical and strategic demands. In addition, the FIFA World Cup™ takes place right after 10-11 months of highly competitive (national and international commitments) and training demands. In fact, national players participating in the world cup take part in more matches during the season than those who do not (1). These previously stated factors are expected to negatively impact players' performances during the 2014 FIFA World Cup™.

In such periods of heavy match commitments, the frequent exposure to match-related biological and psychological stressors may lead to an accumulation of fatigue resulting in match performance impairments (2-4). Nevertheless, the physical performance of elite players seems not to be affected during periods of heavy match commitments (5-7). Moreover, non-significant differences in laboratory, psychometric and performance parameters in elite soccer players with a high vs. a low 3-week match exposure have been reported (8). Therefore, players may adopt some form of pacing strategy that allow to preserve match activities (e.g. high-intensity running) (9).

Despite its importance, there has been no investigation into the physical performances of the FIFA World Cup as a period of the most demanding, competitive and congested fixtures in football. Moreover, most of the studies assessing congested periods did not involve the same cohort of players (6, 10) (not all the players played every match), analyzed the same team (5-7, 10-12) and/or have players with limited time match exposure (7, 12) (e.g. two games in one week). Consequently, the value of the limited time motion research in this area has been questioned (13). In this regard and due to large intra-and-inter match variability (14) in players physical match performance, studies involving more players and teams are needed to detect meaningful variations and generalized trends than studies

involving small-scale cases that represent the core of literature of this field of research (13).

Gain understanding how players distribute their "energy reserves" and manage fatigue during matches may help in the development and implementation of more effective intervention strategies (e.g. nutritional and psychological) (9). Consequently, the present study intended to examine match activity in the same cohort of players from the four first ranked teams during the 2014 FIFA World Cup™. Moreover, given the recent evidence that players may modify their performances to preserve key performance and activity indicators (15) we aim to assist in understanding the dynamic of the activity pattern and effort profile of elite players throughout this type of tournament.

2. Methods

Physical performance data of players from the final four ranked teams of the 2014 FIFA World Cup in Brazil (Germany, Argentina, Netherlands and Brazil) were analyzed. All teams played seven games with an average recovery period of 111 ± 20 hours (range: 90 hours to 146 hours) between games. The performance data were acquired from the official game statistics of the federation internationale de football association (FIFA).

2.1. Participants

A total sample of 17 players (eight defenders, five midfielders and four attackers) were analyzed. Due to the inclusion criteria, six players from Germany, five from Argentina, four from Netherlands and two from Brazil were included in the analysis.

2.2. Procedures

The performance data derived from all the seven matches played in the 2014 FIFA World Cup Brazil™ and were collected from the official FIFA website (http://www.fifa.com/worldcup/archive/brazil2014). This approach has been used in several studies exploring performance metrics in World Cup Final matches (15-23). Detailed system operational guidelines can be found in da Mota et al. (16) and Soroka (21). In summary, the analysis was carried out using data gathered with the Castrol Performance Index game analysis system (CPI). The CPI was first introduced in the 2008 European championships (21, 23). The CPI reports provided a detailed analysis of the teams and players activity throughout the different periods of the matches by means of match motion-analysis with semi-automatic video cameras. This system consists of two sets of four cameras allowing simultaneous tracking of the players' actions during each second of the game and in all sections of the soccer pitch at the speed of 25 frames per second (20, 21). The system measures a) the positions of all players, b) the speed of the players and the ball, c) the distance covered in total or at specific running speeds, d) the team formation, e) interactions among players and f) referee statistics (21). Match activity data of each individual outfield player were recorded as: total distance covered (TD) and the TD in three distinct locomotor categories a) low-intensity running (LIR; < 11 km/h) b) moderate-intensity running (MIR; 11 to 14 km/h) c) high-intensity-running (HIR; > 14 km/h) (15). The frequency of sprints (> 25 km/h) throughout the game was also recorded. In order to be included into the statistical analysis the data of each individual outfield player needed to fulfill two criteria: a) play during the seven matches and b) play at least 85% of the total playing time of the 2014 FIFA World Cup Brazil™ (e.g. 535.5 minutes). The average exposure of the selected players was 97.4% ± 4.1% (range 86% - 100%) of the regular official playing time during the tournament. The absolute data were corrected to an average of distance covered per minutes played for each category (distance divided by effective playing time) to enable equal comparison of performance (24).

In order to decrease the effects of the large intra- and inter-match variability (14) in players' physical match performance, that may mask signs of fatigue during a congested fixture, an identical analysis that investigated temporary fatigue during matches was performed (25). To this end, Z-scores were calculated (statistical analysis section) for the high-intensity parameters MIR and HIR (meter.min^{-1}) and the number of sprints (n.min^{-1}) using all data points collected for each player throughout the tournament. An individual intensity composite score (sum of MIR, HIR and number of sprints Z-scores) was created for each match to provide an indicator of the physical demands. This approach allowed a categorization of players' individual peak performances (peak-game) based on the individual intensity composite score and disregarding the time of its occurrence (e.g. 3rd game) (25). Furthermore, the performance of the subsequent game (e.g. 4th) considered as an important factor and labeled (post-peak performance). The average performance of the remaining five games (average-five) was also calculated. "Temporary fatigue" during the tournament will be evident when the match activity (e.g. sprint) in the post-peak match (game that precedes the peak-game) is lower than the average-five games (25). In this regard, 15 players were analyzed as two players had peak-match performances in their last world-cup match and therefore post-peak performance data was not available. Additionally, a proficiency index was also calculated (HIR/TD × 100). The index was used to understand the stability of the HIR category as part of the total external

work performed (TD) throughout the tournament.

The research material was available at the official FIFA website and did not require any ethical approvals and consent forms. The host institution did not require submission of research for approval as this was an observational, retrospective study dealing with human subjects without directly involving them.

2.3. Statistical Analysis

All data were reported as means, standard deviations (SD) and 95% confidence intervals. Normality was tested with the Shapiro-Wilks test, and assumptions of sphericity were verified. Analysis of variance for repeated measures (ANOVA) was used to compare differences between the different physical parameters of the game, proficiency (HIR/TD $\times$ 100) and intensity composite scores throughout all seven games. The Bonferroni test for multiple comparisons was used to identify specific differences between the means in the different time-points. The Z-score expresses a score with regards to the standard deviation units and is calculated using the following formula (Individual players score - Individual players average)/Individual players standard deviation (SD). For between-variables comparisons in the different locomotor activities and composite scores, a qualitative approach was also used. The true effect or difference determined as higher (i.e. greater than the smallest worthwhile (difference) change, SWC (0.2 multiplied by the between-subject standard deviation, based on Cohen's ES principle]), similar or lower was calculated utilizing a specific designed Excel spreadsheet (26). Threshold values for ES were defined as follows: trivial (< 0.2), small (0.2 - 0.6), moderate (0.6 - 1.2), large (1.2 - 2.0) and very large (> 2.0) (27). The SPSS statistical package (version 18.0; Inc., Chicago, IL, USA) was used in the statistical analysis and statistical significance was set to $P < 0.05$.

3. Results

Total distance covered was significantly and moderately lower in game four ($P < 0.05$, ES = -1.03) and game five ($P < 0.001$, ES = -0.8) than in game one. The TD in game five was significantly and moderately lower than in game six ($P < 0.05$, ES = -0.76). No significant differences were observed between games in the low and moderate-intensity running categories. High-intensity running was significantly lower in game five than in game one (ES = -0.59) and game seven ($P < 0.05$ - 0.01, ES = -0.55). Players perform a significant moderately lower HIR in game five than in game six (ES= -0.6). In addition, players performed a significantly lower number of sprints in game four (ES = -0.76) and five (ES = -0.53) than in game seven ($P < 0.05$). All data are presented in Table 1.

The individual intensity composite score indicates that game five was significantly and largely less intense than game one ($P < 0.005$, ES = -1.21), game six ($P < 0.01$, ES = -1.36) and game seven ($P < 0.005$; ES = -1.37, Table 1 and Figure 1). Nevertheless, match proficiency was stable throughout the world cup matches (Table 1).

Results regarding the distance covered and frequency of activities in different locomotion categories in the peak-game, post-peak and average-five games are presented in Table 2. With exception of the LIR category, all other variables were significantly different from peak-game to post-game and average-five ($P < 0.0001$, ES = 0.6 to 2.9). Although not significantly different ($P > 0.05$), there were substantial changes in LIR (ES = 0.44), sprint (ES = -0.36) and intensity composite score (ES = -0.25) between post-peak and average-five.

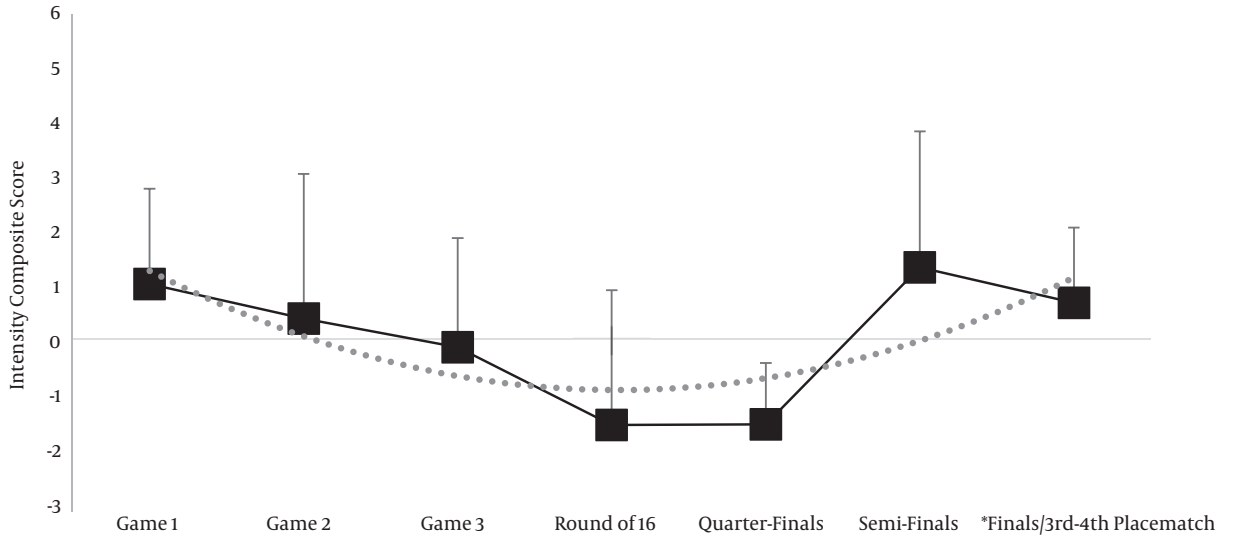
4. Discussion

This is the first study to analyze performance of national players of top ranked teams during the 2014 FIFA World Cup Brazil™. Our analyses suggest that national players from top ranked teams during the 2014 FIFA World Cup Brazil™ did not show a general decline in match activity and players seemed to cope with the physical demands during a congested fixture schedule (seven games in 28 - 31 days). Nevertheless, players showed competitive fatigue-related signs in post-peak match.

These findings are in accordance with previous studies suggesting stability in match physical activity of professional player's during other types of congested schedules (6, 10, 11). However, the different results of this investigation and the previous studies examining similar congested match periods (6 - 8 games in 18 - 26 days) may be related with data sample collection criteria. In fact, other studies involved cohorts with players that did not play all matches, the majority of the match playing time and/or players performances were collected from different congested periods within the season and being part of the same team (5-7, 10-12). In this matter, it has recently been suggested that studies involving more players and teams can be more useful to detect meaningful variations and generalized trends compared to studies involving small-scale cases (e.g. less players and from the same team) (13).

Our results suggest that a reduction in players' match activity may occur during the middle of the tournament (Figure 1). Different situational variables (e.g. quality of opponent, environment conditions and team tactics) might explain the fluctuation in game intensity during congested schedules (28). Nevertheless, the development of residual fatigue or the application of some form of self-regulation of physical activity by players could be a pos-

Figure 1. Dynamic of the Match Intensity Composite Score Throughout the 2014 FIFA World Cup Brazil™ Matches



Dotted Line represents the trendline (polynomial of second order).

Table 2. Distance Covered and Frequency of Activities in Different Locomotion Categories in the Peak Intensity Game, Post-Peak and Average of the Five Remaining Games of the 2014 FIFA World Cup Brazil™

Variables	TD, meter.min^{-1}			LIR, meter.min^{-1}			MIR, meter.min^{-1}			HIR, meter.min^{-1}			SPRINTS, n.min^{-1}			Intensity Composite		
	Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI	
Peak-game	113.4 ± 10.4[a]	107.4	119.1	63.1 ± 2.9[b]	61.5	64.7	19.0 ± 4.7[a]	16.4	21.6	31.3 ± 5.1[a]	28.5	34.1	0.45 ± 0.13[c]	0.38	0.52	3.8 ± 1.04[a]	4.40	3.20
Post-peak	104.3 ± 11.6	97.9	110.7	62.3 ± 4.2	60.2	65.0	16.2 ± 4.8	13.5	18.9	25.5 ± 5.8	22.3	28.7	0.32 ± 0.08	0.27	0.36	-1.1 ± 1.86	-0.09	-2.15
Average-five	102.9 ± 7.6	98.7	107.1	61.2 ± 2.8	59.7	62.8	15.6 ± 3.7	13.5	17.6	26.1 ± 4.5	23.7	28.6	0.35 ± 0.10	0.30	0.40	-0.53 ± 0.46	-0.28	-0.78

Abbreviations: HIR, High-Intensity Running; Intensity Composite Score, Sum of the Z-scores in the Moderate-Intensity Running, High-Intensity Running and Number of Sprints Category; LIR, Low-Intensity Running; MIR, Moderate-Intensity Running; TD- Total Distance Covered.
[a] Significantly different Peak-game vs. Post-game and average-five ($P < 0.001$).
[b] Significantly different Peak-game vs. average-five ($P < 0.05$).
[c] Significantly different Peak-game vs. Post-game and average-five ($P < 0.005$).

sible explanation. Research has shown that some central and peripheral fatigue indicators (e.g. glycogen resynthesizes, maximal voluntary activation) (4, 29-33) as well as physical performance parameters (4, 29, 33) may be completely restored within the utilized recovery periods of < 90 hours. These periods are shorter than the ones used in 2014 FIFA World Cup Brazil™ (range: 90 hours to 146 hours). Players may be able to efficiently perform at neuromuscular and metabolic levels and maintain performance during congested schedules (6, 10, 11). Meister et al. (8) observed that a 3-week period of high match exposure in elite football players did not affect laboratory, psychometric and performance parameters. Nevertheless, the upper limit of match exposure time in the mentioned study (347 minutes) is considerably less than the players included in this study (630 minutes).

The reported high match-to-match variability in performance characteristics within players and teams (14) as well as players' rotation strategies adopted by coaches are factors that may mask fatigue signs within congested schedules. However, it seems also plausible that signs of transient/residual fatigue during a congested fixture schedule could be observed after a peak-game. A very intensive game requiring higher match physical activity may exacerbate physiological, biological and perceptual responses than the more typical encountered (14, 34, 35). Our analyses revealed substantially small possibly differences for the number of sprints and intensity composite score between post-peak match and average-five matches. These previous observations may suggest that players may experience an extended period of residual fatigue after peak-match. These findings reinforce the necessity of indi-

vidual performance monitoring within congested match schedules.

Interestingly, descriptive analysis of the peak-game revealed that from the 17 players analyzed, three players had peak-game in game one, five players in game two, one player in game three and game four, five players in game six and two players in game seven. The players' individual intensity composite score shows that a reduction in player's match activity occurred during the middle of the tournament; the quarterfinals were significantly less intense than game one, six and seven (Figure 1 and Table 1, ($P < 0.05$)). This match running performance fluctuations may be indicative of fatigue, situational influences or pacing (24). It has been argued that players may apply a pacing scheme that can be updated (throughout the tournament) in response to physiological cues (9). According Waldron and Highton (9) "Pacing is considered as the distribution of energy resources that optimize match-running performance to suit the requirements of a given scenario". As so, a multi-level pacing model could have been applied, based on both pre-match (intrinsic and extrinsic factors) and dynamic considerations during the game (e.g. accumulation of metabolites in the muscles) (36)). This rational could also be applied from a congesteded schedule perspective at the 2014 FIFA World Cup Brazil™. In fact, the player's inability to predict the exact end-point (90 minutes or 120 minutes during knock-out phase) of the game is considered an determinant factor in the type of pacing strategy to be adopted by players (length of the bout) (9). The adoption of pacing strategies by players may ultimately result in different match activity profiles (e.g. U, J or reverse J-shaped curve) (37).

Interestingly and despite observed differences in TD and HIR between distinct matches, match proficiency (an index of the percentage of HIR of the TD) throughout the 2014 FIFA World Cup Brazil™ was stable and had a low CV (8.4%). Moreover, it's also important to note that from the inclusion criteria six players from Germany, five from Argentina, four from Netherlands and two from Brazil were included in the analysis. This leads us to suggest that the ability and/or capacity to maintain a core of the team throughout the tournament may have had an impact on the final ranking of the four first ranked teams. Even though, it should be kept in mind that team selection by coaches is influenced by voluntary (strategic tactical options) and involuntary issues (e.g. injuries and suspensions). Further studies should utilize a multi-dimensional approach, ranging from perceptual responses to performance and biochemical markers to understand if this variation in match physical performance is due to residual fatigue per se or to a modulation of effort during the tournament. This study possesses some limitations that limit the generalizability of the findings. Notwithstanding other factors, the circumstance that team tactics may influence individual performances and that no physical performance and biochemical markers were monitored is the greatest limitation.

The results of the present study suggest that players with a high match exposure from top ranked teams during the 2014 FIFA World Cup Brazil™ did not show a general decline in match activity. The general absence of competitive fatigue-related markers reveal the importance of players arriving to the world cup in good physical status. The substantial decrements in the number of sprints after peak-match performance reinforce the necessity of individual performance analysis (e.g. understand when the player has the most demanding "challenge" from a chronic point of view). This information may contribute to assisting coaches in the development and implementation of more effective intervention strategies (e.g. nutritional) and in training load adjustments throughout the tournament (e.g. after peak-match). In fact, it seems favorable for tournament outcome to maintain a greater proportion of the team core throughout the tournament.

Footnote

Authors' Contribution: Study concept and design (JRS and MR) Acquisition of data (JRS, MR, MH) Analysis and interpretation of data (JRS, MR, MH) Drafting of the manuscript: (JRS, MR) Critical revision of the manuscript for important intellectual content: (JRS, MR, MH, GN) Statistical analysis: (JRS, MH) Study supervision: (JRS, MR, GN)

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Table 1. Distance Covered and Frequency of Activities in Different Locomotion Categories Trough the Group Phase and Knock-Out Phase of the 2014 FIFA World Cup Brazil™

Variables	Group Phase (1 - 3)									Knock-Out Phase (4 - 7)												
	Game 1			Game 2			Game 3			Game 4			Game 5			Game 6			Game 7			
	Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		Mean (SD)	95% CI		
TD, meter.min^{-1}	108.6 ± 9.8	103.6	113.7	107.3 ± 12.4	101.0	114.0	105.0 ± 9.8	100.0	110.1	96.5 ± 10.4[a]	91.2	101.9	100.9 ± 7.9[b]	96.8	104.9	108.8 ± 11.3	103.0	114.6	105.3 ± 8.8	100.8	109.9	
LIR, meter.min^{-1}	63.0 ± 2.4	61.8	64.3	62.8 ± 3.6	61.0	64.7	61.8 ± 4.4	59.5	64.1	57.4 ± 7.9	53.4	61.5	61.1 ± 3.7	59.1	63.0	63.2 ± 3.6	61.3	65.0	61.4 ± 3.1	59.7	63.0	
MIR, meter.min^{-1}	17.2 ± 4.6	14.8	19.5	17.1 ± 4.7	14.6	19.5	16.5 ± 4.4	14.2	18.7	14.9 ± 3.0	13.4	16.5	15.0 ± 3.7	13.1	16.9	17.2 ± 4.2	15.0	19.3	16.1 ± 3.8	14.1	18.1	
HIR, meter.min^{-1}	28.4 ± 6.3	25.2	31.6	27.4 ± 7.1	23.7	31.0																
26.7 ± 4.6	24.4	29.1	24.2 ± 4.4	21.9	26.4	24.8 ± 4.4[c]	22.5	27.1	28.5 ± 6.0	25.4	31.6	27.9 ± 5.7	24.9	30.8								
SPRINTS, n.min^{-1}	0.38 ± 0.14	0.31	0.46	0.35 ± 0.13	0.28	0.42	0.34 ± 0.11	0.28	0.40	0.31 ± 0.10[d]	0.26	0.36	0.33 ± 0.09 ≠	0.28	0.37	0.40 ± 0.13	0.33	0.47	0.39 ± 0.10	0.34	0.44	
Intensity Composite	1.02 ± 1.77	0.10	1.90	0.37 ± 2.69	-1.01	1.76	-0.17 ± 2.03	-1.21	0.88	-1.61 ± 2.51	-2.90	-0.32	-1.60 ± 1.15[e]	-2.19	-1.01	1.32 ± 2.53	0.02	2.61	0.67 ± 1.40	-0.06	1.39	
Proficiency, %	25.9 ± 3.8	23.9	27.8	25.1 ± 4.1	23.0	27.2	25.4 ± 3.0	23.9	26.9	25.0 ± 3.6	23.1	26.9	24.5 ± 3.1	22.9	26.1	26.0 ± 3.3	24.3	27.7	26.2 ± 3.8	24.2	28.1	

Abbreviations: HIR, high-intensity running; Intensity Composite Score, Sum of the Z-scores in the Moderate-Intensity Running, high-Intensity Running and Number of Sprints category; LIR, Low-Intensity Running; MIR, Moderate-Intensity Running; TD, Total Distance Covered.

[a] Significantly different from game1 (P < 0.05).

[b] Significantly different from game 1 (P < 0.001) and game 6 (P < 0.05).

[c] Significantly different from game 1 (P < 0.05), game 6 (P < 0.01) and game 7 (P < 0.05).

[d] Significantly different from game 7 (P < 0.05).

[e] Significantly different from game 1 (P < 0.005), game 6 (P < 0.01) and game 7 (P < 0.005).