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Research article

The Relationship of Practice Exposure and Injury Rate on Game Performance and Season Success in Professional Male Basketball

Toni Caparrós [1,2]✉, Eduard Alentorn-Geli [3], Gregory D. Myer [4,5,6], Lluís Capdevila [7], Kristian Samuelsson [8], Bruce Hamilton [9] and Gil Rodas [10]

[1]Insititut Nacional d'Educació Física de Catalunya (INEFC), Barcelona, Spain; [2] SPARG Research Group, Universitat de Vic, Vic, Spain; [3] Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA; [4] Division of Sports Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; [5] Departments of Pediatrics and Orthopaedic Surgery, University of Cincinnati, Cincinnati, Ohio, USA; [6] The Micheli Center for Sports Injury Prevention, Boston, MA, USA; [7] Laboratory of Sport Psychology, Universitat Autònoma de Barcelona, Barcelona, Spain; [8] Department of Orthopaedic Surgery, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden; [9] High Performance Sport New Zealand, Auckland, New Zeland; [10] Medical Department, Futbol Club Barcelona, Barcelona, Spain

Abstract

The objectives of this study were to determine the relationship among game performance, injury rate, and practice exposure in a professional male basketball team. A retroospective analysis of prospective collected data was conducted over seven consecutive seasons (2007/2008 to 2013/2014). Data collection included sports performance during competition (statistical evaluation), injury rate, and total exposure (games and practices). Over the surveillance period, 162 injuries (91 practice; 71 matches) occurred over 32,668 hours of exposure (556 games and 2005 practices). There was a strong positive correlation between: 1) exposure (total number of practices and hours of exposure) and the total number of injuries ($r = 0.77$; $p = 0.04$); 2) exposure (total hours of exposure and total hours of practice exposure) and performance (total team ranking) ($r = 0.77$ and $p = 0.04$, and $r = 0.8$ and $p = 0.03$, respectively); and 3) total number of injuries and performance (total team ranking) ($r = 0.84$; $p = 0.02$). While increasing practice and competition time is related to greater team performance, it also increases the number of injuries. However, higher injury rates were not associated with worse overall team performance. Efforts to reduce high-risk activity during practice, optimally replaced with injury prevention training, might help to reduce injury risk.

Key words: Injury, basketball, professional, training load, performance.

Introduction

Winning in professional sport requires the optimal mix of sport specific training to optimize conditioning while limiting exposure to injury risk scenarios (Fuller et al., 2012). In this context, to objectively measure the impact of training and practice models relative to injury incidence require the systematic aggregation of both health- and performance-related parameters integrated into all aspects of training and competition (Carling and Court, 2012; Hughes and Franks, 2004). Ultimately, the goal to monitor training response is to allow for the assessment and adjustment of planification and, thus, optimize team gains. An effective season planning should prevent training load error (Claudino et al., 2012; Gabbett and Ullah, 2012; Strudwick, 2012), optimize recovery, minimize load-related risk factors (Bangsbo et al., 2006; Fuller et al., 2012; McGill et al., 2012; Hagglund et al., 2013) and decrease rates of injury (Raysmith and Drew, 2016). This will provide the best opportunity for injury-free season success.

The success of a basketball team may be influenced by many factors (Kazimierz et al., 2013), requiring a multifactorial assessment that allows every game success and performance to be evaluated in a translatable and objective way (Hughes and Franks, 2004; Gomez Ruano et al., 2008). Hence, in professional basketball numerous forms of performance data are routinely collected, precisely and objectively evaluating player and team performance variables (Hughes and Franks, 2004; Strudwick, 2012). Similarly, epidemiological methods for capturing both injury incidence and exposure are well established (Hagglund et al., 2005).

Epidemiological research has been performed in basketball (Caine and Maffulli, 2005; Borowski et al., 2008; Newman and Newberg, 2010), and some studies have investigated relationships between training, competition and injury rates (Manzi et al., 2010; McGill et al., 2012). However, currently one study has integrated performance data, exposure and injury rates at the professional level (Podlog et al., 2015). In addition, there is limited integration of game data and injury epidemiological research into real competition and training periods (Caparrós et al., 2014). Therefore, the purpose of this investigation was to determine the relationship among game performance, injury rate, and practice exposure in professional male basketball.

Methods

The local research ethics committee (Consell Català de l'Esport, Barcelona, Generalitat de Catalunya Nº 162015CEICGC) approved the study. Study participants were informed of the purpose and nature of the study and were given the opportunity to decline inclusion of their data. Players were assigned an individual identifier code with the identity concealed, ensuring player anonymity was maintained.

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Design
A retrospective study of prospectively collected data during seven consecutive seasons, 2007/2008 to 2013/2014, from an professional basketball team (F.C. Barcelona) that played three main competitions every season: Liga ACB (Spanish Division 1 Championship), Spanish Cup (Play-off competition) and Euroleague (European top division Championship). Players were evaluated at the beginning of each season using the Futbol Club Barcelona (FCB) periodic health examination protocol. The Team Physician (Gil Rodas) was responsible for diagnosis, rehabilitation and return-to-play for each injury, as well as recording of all injuries included in the current investigation.

Data collection
Data collected for this study included 3 main parameters:

1) Exposure time: Exposure for individual players was measured as both the number and hours (h) for games and number and hours for total practice sessions. Exposure aggregation was considered from the beginning until the end of the season. Game time was defined as the hours that each player played competitive games, and practice time refers to specific team practice on court, conditioning and injury prevention workouts.

2) Injury: This data collection was based on the methodology of the Union of European Football Association (UEFA) consensus statement for injury incidence collection (Hagglund et al. 2005). A time-loss injury (TLI) was defined as any injury occurring during a practice season or matches which caused an absence for at least the next practice session or match. Each individual data was recorded daily after every practice and game by the Team Physician (Gil Rodas). Time-loss from associated injuries were retrospectively categorized based on severity, as determined by the number of days of absence from participation. Incidence was calculated as the number of injuries per 1000 player hours (Σ injuries/Σ exposure h×1000), depending whether the event occurred in practice or in competition. Every injury was considered as an independent case. Each player could have more than one injury.

3) Performance statistics were collected from the official game statisitics for both the team and player. At the end of each game the official ranking (RKG) quantified for each player the scored points (SP), missed shots (MS: 2 points, 3 points and free throws), total rebounds (R) (offensive plus defensive), assists (A), steal balls (ST), turnovers (T), blocks received (BA), blocks made (BM), faults incurred (FC) and faults received (FR). From these values a positive or negative ranking number is obtained based on the following formula (Gomez Ruano et al. 2008): RKG= (SP + R + A + ST + T + BM) - (MS + T+ FC). For each season, the total team ranking, mean game ranking, mean player ranking and the mean player scored points were calculated. Championships achieved and performance outcomes were also recorded.

Statistical analysis
Data was recorded for each player and season and was accumulated to provide mean team values. Those mean team values were correlated with an outcome parameter (sport performance, injury rate or exposure time) for each season using a Pearson's correlation (r). This coefficient ranges between -1 and +1. Data analysis was performed with IBM SPSS Statistics for Windows (Version 20.0, IBM Inc., Armonk, NY, USA). The alpha level was set to $p < 0.05$.

Results

Participants
The sample consisted of 44 players: mean ± SD age of 27.6 ± 4.1 years, height of 2.00 ± 0.09 m, and mass of 98.5 ± 12.6 kg) from a Spanish basketball club (F.C. Barcelona). Two players played at the team during six seasons; one during five; five players over four seasons; four over three, eleven over two, and forty four of them took part at least one season (1.7 ± 1.2 seasons per player) with mean value of 13.0 ± 0.9 players per season. The characteristics of the players are shown in Table 1. The team had a mean of 286 practices and 80 games played per season, with a total exposure of 4667 hours during 10-month seasons.

Performance outcomes
During the study period the team won eight competitions (four Spanish Championships, three Spanish Cups and one European Championship) and achieved a top four qualification on five additional occasions. The most successful season was 2009/2010 when three performance objectives were achieved (Spanish Cup, Final 4, and European Championship) (Table 2).

Injury and exposure
The exposure to practice and games, exposure hours, injury incidence and performance values are presented in Table 2. There was a positive correlation between exposure (total number of practices) and the total number of injuries ($r = 0.77$; $p = 0.04$).

Exposure, injury and performance relationships
The correlation between practice and game exposure, injury incidence and performance outcomes is shown in Table 3. A strong positive correlation was observed between exposure (total hours of exposure and total hours of practice exposure) and performance (total team ranking) ($r = 0.77$ and $p = 0.04$, and $r = 0.8$ and $p = 0.03$,

Table 1. General description of study participants. Data are presented as mean (SD).

Seasons	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Total Mean
N	12	12	13	14	12	14	14	13.0 (.9)
Age (y)	27.2 (4.2)	26.7 (3.6)	27.8 (3.9)	29.1 (4.2)	28.2 (3.4)	27.4 (4.7)	26.5 (4.8)	27.6 (.8)
Height (m)	2.00 (.10)	1.99 (.08)	1.99 (.09)	2.00 (11.4)	2.02 (.09)	2.00 (.08)	2.00 (.010)	2.00 (.08)
Weight (kg)	96.7 (13.1)	98.8 (13.3)	95.5 (9.1)	97.6 (11.4)	97.8 (9.1)	103.0 (16.6)	100.1 (15.3)	98.5 (2.3)

Table 2. **Number of practices and games, hours of exposure, incidence and number of injuries, and performance by season. Data are presented as total frequency and mean (SD).**

Seasons	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Total Mean per season
Exposure								
Total number of practices	283	276	268	288	281	305	304	286 (13)
Total number of games	78	79	78	72	76	88	85	79 (5)
Total number exposure hours	4540	4788	4438	4416	4060	5364	5063	4667 (407)
Total game exposure hours	244	248	227	216	243	286	264	247 (21)
Total practice exposure hours	4296	4540	4212	4200	3817	5077	4799	4420 (389)
Injuries								
Total number of injuries	13	18	21	26	17	37	29	23 (8)
Total number injuries during practice	8	11	12	11	11	16	22	13 (4)
Total number injuries during game	5	7	9	15	6	21	7	10 (5)
Total Injury Incidence per 1000 h	2,9	3,8	4,9	5,9	4,2	6,9	5,7	5 (1)
Total Injuries per 1000 h of practice	1,9	2,4	2,8	2,6	2,9	3,1	4,6	3 (1)
Total injuries per 1000 h of games	20,5	28,2	39,7	69,4	24,7	73,4	26,5	40 (20)
Performance								
Total outcomes achieved	1	2	3	2	3	2	2	2 (1)
Total team ranking	5406	6285	6465	5795	6344	7952	7427	6525 (822)
Team mean game ranking	77,4 (15,3)	91,7 (17,8)	94,1 (19,3)	88,2 (14,9)	88,9 (18,2)	92,7 (20,0)	93,8 (20,9)	90 (5)

Table 3. **Correlation between number of practices and games, hours of exposure, incidence, number of injuries per season and performance.**

Performance	Total team ranking		Mean game ranking		Mean player ranking		Mean player scored points	
	r Pearson	p	r Pearson	p	r Pearson	p	r Pearson	p
Exposure								
Total number of practice	.67	.09	.14	.75	.52	.23	**.77 ***	**.04**
Total number of games	**.87 ***	**.01**	.39	.39	.57	.18	.71	.74
Total hours exposure	**.76 ***	**.04**	.35	.44	.48	.27	.70	.77
Total hours practice exposure	**.80 ***	**.03**	.23	.61	.51	.24	.43	.34
Total hours game exposure	.75	.54	.35	.43	.48	.28	.71	.07
Injuries								
Total number of injuries	**.84 ***	**.02**	.59	.16	**.82 ***	**,02**	**.92 ****	**<.01**
Number of injuries during practice	**.83 ***	**.02**	.64	.12	**.76 ***	**.04**	**.75**	**.05**
Number of injuries during game	.53	.22	.33	.47	.56	.19	.67	.09
Total injury incidence per 1000 h	.75	.05	.65	.11	**.84 ***	**.02**	**.88 ****	**<.01**
Practice injury incidence per 1000 h	.75	.05	.67	.10	**.76 ***	**.05**	.67	.10
Game injury incidence per 1000 h	.35	.44	.30	.52	.47	.29	.60	.0.15

* $p < 0.01$; ** $p < 0.005$.

respectively). Also, there was a strong positive correlation between the total number of injuries and performance (total team ranking) outcomes ($r = 0.84$; $p = 0.02$), and between total number of injuries and mean player scored points ($r = 0.92$; $p < 0.01$). The total injury incidence per 1000h of exposure was positively correlated with the mean player scored points ($r = 0.88$; $p < 0.01$). In addition, the number of injuries during practice was positively correlated with the mean player ranking ($r = 0.76$; $p = 0.04$).

Discussion

The present study investigated the relationship among game performance, injury rate, and practice exposure in a professional male basketball team. The main finding of the study was that successful and unsuccessful seasons were not affected by the rate of injury. However, in successful years, the season was prolonged and there were a greater total number of practices, games and number of injuries.

The 2012/2013 and 2013/2014 seasons had the highest training and competition exposure (5364 and 5063 hours respectively) and the team achieved 2 main performance outcomes, rating 2nd and 3rd in rankings (92.75 and 93.84 respectively). During the best performing season (2009/2010) the team had its highest ranking (94.81), with a total exposure of 4438 hours. During the 2007/2008 season, total exposure was 4540 hours, only one title was achieved and the lowest ranking (77.4) was observed. High exposure are generally associated with better performance, but is important to note that there was also success in seasons where the total exposure time, number of injuries and team ranking were below the average. The data presented suggest that practice load can lead to improved levels of performance, being high enough to reach adaptations to competition demands and success.

Successful seasons were associated with a higher number of practices and games (longer seasons), but also with a greater number of injuries. These findings are consistent with those reported by other authors, who have reported higher injury rates associated with increased volumes of exposure in team sports as related to soft tissue injuries in rugby (Gabbett and Ullah, 2012) or mi-

nor injuries in football (Eirale et al. 2013), but not for total injuries as observed in this study.. However, no previous studies have reported the injury rates associated with exposure in professional basketball or throughout several seasons. During the 2009/2010 and 2011/2012 seasons, when exposure to practice and games was lower, the total injuries incidence per 1000h of exposure (4.9 and 4,2 per season, respectively) was under or on the mean of injury incidence considering the entire study period (4.9 1000h of exposure per season). Similarly, seasons 2012/2013 and 2013/2014 had the highest exposure to games and practice and the highest number of injuries (6.9 and 5.7, see Table 2).

There is a considerable variability in the total number of games and length of season clearly dependent on team performance. A clear example occurs when teams get further in the Euroleague, as it entails an addition of up to 10 games to regular season (from 2012/2013). The total number of injuries may be associated with the length of season, as players are more exposed to situations where they may potentially get injured (practice and games). Hence, the better a team performs, the more games a team plays (because the team continues on competition) and the more injuries may occur (Gabbett and Ullah 2012).

The positive correlation between injury rates and performance indicates that player injuries are most likely to occur in the best players; however they are not detrimental as detrimental to season team success in elite basketball as hypothesized. This has been also observed by other authors in football (Ekstrand et al. 2011; Eirale et al. 2013; Hagglund et al. 2013). McGill et al. (2012) relate more back injuries in basketball trend to more games played (28.60 ± 9.29), more minutes (21.72 ± 11.63), and greater number of rebounds (3.16 ± 2.61), and steals per game (0.67 ± 0.34). At professional level (NBA), Podlog et al. (2015) found a negative relationship between team performance (number of winning games) and injury rates ($r = -0.29$; $p < 0.001$). The challenge is therefore to provide adequate training loads to improve performance and fitness but with enough protective effect against injuries (Drew and Finch, 2016; Gabbett, 2016). It should be noted that injuries may have a negative effect on season performance in case of short rosters, or rosters where main roles (in terms of minutes played and rotations) and team structure and playbook have less flexibility than in Europe. Thus, well-funded European teams have large rosters to prevent a negative effect of injuries on team goals. This implies trying to have at least 12 top players, which is the maximum number of player that can participate on a match, regardless the number of injuries. This availability of player replacement may therefore have a confounded our ability to measure the impact of injury on team outcomes.

The findings of the present study indicate that the there is an elevated risk of injury during competition compared to practice. This observation is consistent with those reported with other team sports like European football (Ekstrand et al., 2011), rugby (Gabbett and Ullah, 2012), or Gaelic football (Murphy et al., 2012). Load management by reduction in the number of practices and its duration has been shown to reduce injury rates and fatigue (Gabbett, 2004; Frisch et al., 2011). However, a reduction of hours of practices to reduce the number of injuries does not seem a good strategy to improve team performance. Therefore, an adequate balance between training load and fatigue recovery and overload prevention is required in order to assure an adequate overall team performance requirements (Gabbett, 2016). In other words, there should be an optimal balance between competition and practice exposure time and time to recover (Ekstrand et al., 2011; Mendiguchia and Brughelli, 2011). In addition, efforts to reduce high-risk activity during practice, optimally replaced with injury prevention training might help sport performance and reduce injury risk.

The overall season design and planning should take into account the need for increased practice and competition time to improve performance (Rogalski et al., 2013). While the season planning is determined by the in-season performance (the more a team wins, the more the team plays), the optimal training (Krustrup et al., 2003) should consider some of the findings of the present study: the positive relationships between injury incidence and mean player ranking, and between total injuries and exposure to practice. It is important to note that a specific intervention on offensive players may be required, as these players have usually a higher physical pressure by opponent defenders and the need for scoring itself, that make them potentially exposed to a higher risk of injury (Kazimierz et al., 2013; Lago-Penas et al., 2010; Oliver, 2005).

The present study has some limitations. First, the results of the present study only refer to one professional basketball team. However, data correspond to 7 consecutive seasons and may therefore truly represent injury patterns in elite basketball. Second, the exposure has only been measured as hours of exposition, and has not involved a comprehensive quantification of external and internal loads. Further studies may be conducted to investigate the association between external and internal loads and injury rates. Third, performance was only quantified using the team ranking. Although this is a well-established performance parameter, other indicators of performance could have been used. However, the strength of this study is to report data on the association between training load, injury rates, and team performance over a 7-season period in a professional basketball team. The study highlights the need for a correct balance between team and individual planning on training loads and in-season recovery periods after games. Further research should be conducted to determine the optimal balance between training load, season performance and injury prevention, and to investigate other factors that may be related to team performance.

Practical applications

The season planning should be performed according to the minimum and potentially maximum length of the season (number of games). Injury prevention programs may not have a significant impact on overall season success unless they replace activities that can reduce overall training volume. Therefore, implementation of prevention

programs should be performed on with team programming in mind and be individualized to each athlete according to its risk of injury.

Conclusion

While increasing practice and competition time is related to greater team performance, it also increases the number of injuries. However, higher injury rates were not associated with worse overall team performance.

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Key points

- Increasing practice and competition time is related to greater team performance.
- Increasing practice and competition time increases the number of injuries.
- Higher injury rates were not associated with worse overall team performance.

AUTHOR BIOGRAPHY

Toni CAPARRÓS
Employment
Strength and Conditioning coach, Spanish National Team Sports Science Advisor Memphis Grizzlies
Degree
BSc, MSc, MSo, MBA, PhD
Research interest
Training load and performance, influence of injuries on performance, elite basketball players
E-mail: info@tonicaparros.eu

Eduard ALENTORN-GELI
Employment
Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA.
Degree
BSc, MD, MSc, PhD, FEBOT, FACGME
Research interest
Shoulder and elbow injuries
Shoulder and elbow surgery
Knee and Sports Traumatology
E-mail: ealentorngeli@gmail.com

Gregory D. MYER
Employment
Director of Research
Director of the Human Performance Laboratory, Division of Sports Medicine, Cincinnati Children's Hospital
Degree
PhD, FACSM, CSCS*D
Research interest
Injury biomechanics, human performance, pediatric exercise science, preventive medicine, sensorimotor neuroscience.

Lluís CAPDEVILA
Employment
Professor, Director of Sport Psychology Laboratory, Universitat Autònoma de Barcelona, Barcelona Spain.
Degree
PhD
Research interest
Health and lifestyle, sports performance.
Health Sport Psychology

Kristian SAMUELSSON
Employment
Faculty, Department of Orthopedic Surgery, Sahlgrenska Academy, University of Gothenburg, Mölndal, Sweden.
Degree
MD, PhD
Research interest
Knee injuries, Sports traumatology, Sports performance

Bruce HAMILTON
Employment
Sports physician, High Performance Sport, NZ
Degree
MD
Research interest
Sports injuries, Sports performance, Muscle injuries

Gil RODAS
Employment
Team physician, F.C. Barcelona, Barcelona, Spain
Degree
MD, PhD
Research interest
Sports injuries, Sports traumatology, Sports performance, Muscle injuries

✉ **Toni Caparrós**
c/Sant Joan Bosco 7-9, 08338, Premia de Dalt, Barcelona, Spain