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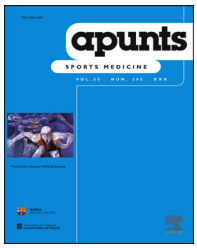

ORIGINAL

Relationship between injury risk, workload, and rate of perceived exertion in professional women's basketball

Relación entre lesionabilidad, carga de entrenamiento y percepción del esfuerzo en el baloncesto femenino profesional

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KEYWORDS
Injury;
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Abstract In order to better understand the possible relationships between the application of training loads and the risk of injury in professional women's basketball, four parameters from a professional women's basketball team ($N = 11$) were analysed: exposure time, number of injuries, rate of perceived exertion (RPE), and workload (sRPE). A total of 3182 h of exposure were registered, 2774 were training hours, and 408 were game hours with a total of 9 time loss injuries. The data obtained from each player was related to the exposure time, injury risk, perception of effort, and workload. Several differences were observed between the injury risk values and the morning RPE ($F = 5.0811$; $p = .032$), the sRPE of the morning practices ($F = 7.3585$; $p = .010$) and the total time of exposure ($F = 3.5055$; $p = .064$). There is also a significant negative relationship between total training time and the number of time-loss (TL) injuries (rho = −.797; $p = .003$), as well as a possible association between exposure time and a lower risk of TL injury ($R^2 = .645$). These findings suggest that an increase in specific exposure time could be associated with a decrease in the risk of time-loss injuries.

PALABRAS CLAVE
Lesión;
Deportes de equipo;

Resumen Con el objetivo de entender mejor las posibles relaciones entre la aplicación de cargas de entrenamiento y el riesgo de lesión en el baloncesto femenino profesional, se analizaron 4 parámetros de un equipo de baloncesto femenino profesional (N = 11): tiempo de exposición,

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número de lesiones, percepción del esfuerzo después de las sesiones entrenamiento (RPE) y carga de entrenamiento (sRPE). Se registraron 3.182 horas de exposición totales, de las cuales 2.774 fueron de entrenamiento y 408 h de competición con un total de 9 lesiones *''time-loss'' (TL)* que comportaron tiempo de actividad perdido. Se relacionan los datos obtenidos de cada jugadora relativos a tiempo de exposición, lesiones, percepción del esfuerzo y carga de trabajo. Se observan posibles diferencias entre los valores de lesionabilidad y RPE de las sesiones de entrenamiento de la mañana (F = 5,0811; p = 0,032), el sRPE de la mañana (F = 7,3585: p = 0,010) y el tiempo total de exposición (F = 3,5055; p = 0,064). Se observa también una relación significativa negativa entre tiempo total de entrenamiento y el número de lesiones TL (rho = -0,797; p = 0,003), así como una posible asociación entre el tiempo de exposición y una menor incidencia lesional TL (R2 = 0,645). Estos valores sugieren que un aumento del tiempo de exposición de carácter específico podría vincularse a la disminución del riesgo de lesiones *''time-loss''*.

Introduction

Basketball is an intermittent sport with short and intense actions usually under 3 s long, and with longer periods of moderate activity and recovery.[1] Cardiovascular demands are high, with emphasis on aerobic metabolism and anaerobic glucolysis[2] as the main sources of energy and a maximum theoretical heart rate mean of 89% during games.[3] Winning in the professional sport requires the optimum combination of specific sports training to perfect performance and limited exposure of the sportsperson to injury risk settings.[4] With the appropriate training, the sportsperson's state of fitness may be improved and injury risk lowered.[5] Along these lines, physical preparation with light loads, aimed at qualitative execution of motion and specific guidance is useful in strength training in basketball.[6]

In women's basketball[7] the physical and physiological demands imposed on the players during games are defined as high (87.55% theoretical maximum HR), and it is described as a high intensity intermittent sport.

In women's basketball the intensity and frequency of training has to be adapted to the chronological and biological age of the players to prevent serious injuries.[8] Some anthropometric and physical aptitude characteristics of the teams and players are associated with parameters relating to performance.[9] In this specific context, high chronic training loads accomplished in the appropriate manner are associated with a lower risk of injury and better performance.[10] In fact, high and very high training loads imposed on the sportsperson in a chronic fashion may even protect them from suffering an injury.[11]

However, if these high loads are accomplished acutely and sporadically they appear to increase the risk of injury significantly.[12] Based on this premise it was observed in the past that there was a negative relationship between specific training time and total injuries.[13] It has also been possible to assess that an increase in training time and greater volume of competitions is linked to higher team performance.[14]

In order to be able to control all of these variables, professional sport requires monitoring of the training load and a scheduling of the conditional contents aimed at the availability of the sportsperson and the prevention of injuries.[15]

The goal of monitoring is to perfect the training process and facilitate decision-making during training.[16]

The rate of perceived exertion (RPE) is a useful tool for monitoring internal load in basketball.[17] The use of this perception once the session has terminated (sRPE) is a valid indicator of internal load (RPE $\times$ min)[18]. The RPE provides us with a mechanism to quantify the intensity and allows us to calculate the workload on multiplying it by exposure time.[19] Monitoring training load with this system should be performed individually and take into consideration recovery strategies when the sportsperson is very tired.[20] Weekly load increases should be individually reviewed, correctly monitoring so as to avoid increases higher than the sportsperson's ability to tolerate them.[21]

The aim of this study is to better understand the possible relationships between the application of training loads and the risk of injury in professional women's basketball.

Materials and method

Participants

Eleven members of a professional women's highest state level (women's league 1) basketball team took part in the study during the 2017–2018 season. The mean age of these players was 23.36 $\pm$ 2.99 years, with a mean height of 182.18 $\pm$ 9.59 cm and weight of 78.64 $\pm$ 13.94 kg.

All the players, trainers and managers of the team were informed about the research protocol and signed their informed consent prior to study commencement.

Data usage complied with the 1964 Declaration of Helsinki standards, reviewed in Fortaleza in 2013.[22]

The players were given an individual identification code to hide their identity, guaranteeing personal data protection

Table 1 Variables and units of measurement.

Variables	Units of measurement
Time of exposure	Hours
Injury	Number of each type
RPE	CR-10
sRPE	Time of exposure × RPE

in compliance with the European Parliament General Data Protection Registry (GDPR).

Planning the seasons

The season had a total duration of 32 weeks and its planning was divided into 3 phases. The first of these, the pre-season, lasted 6 weeks. In keeping with the competitive aims of the team, the aim of this initial phase was specific conditional improvement to start competing in an optimum state of fitness. After this, a second phase of 13 weeks was structured which corresponded to the entire first round of the competition, aimed at maintaining a state of competitive fitness and a third phase, also lasting 13 weeks, during the second round of competition, assuming optimum states of competitive fitness at the end of this phase.

The total duration of the study was 32 weeks, the total season.

Variable recording

This study included 4 main parameters (Table 1). Exposure time: the exposure of the players was individually measured with the following variables: number and hours of competition and number and hours of total training. This follow-up was made from the beginning until the end of the season. Game time was defined as the hours each player played in these games, and the training time referred to morning and evening sessions of the team on the court. The individualised work of each player was also recorded so as to collect the maximum details of exposure time.

Injury: the methodology used for data collection was that proposed in the agreement of the Union of European Football Associations (UEFA) for defining injury and for data collection of injuries which occurred during the study.[23] A time-loss (TL) lesion was defined as any injury which occurred during training or a game and which led to the absence for at least the following session or game. Each individual data was recorded daily after each training session and game by the team's fitness coaches. Time loss from injuries was classified retrospectively based on their severity, determined by the number of days absence in participation.

Rate of perceived exertion (RPE): recording of the RPE was made on an individual basis 30 min after finalising each training session. Once the session had finished this was sent using the messaging application of *Whatsapp Messenger version 2.19.134 (Facebook Inc., California, USA)* with a reminder message to each player and they sent the RPE through a private message. Once received this was recorded on the database. The scale used for exertion classification was that of Borg CR-10 where 1 was a very mild exertion and 10 was maximum exertion. The RPE was revealed in previous studies to be a valid method for quantifying training loads in sport for an intermittent team of high intensity.[18]

Workload (sRPE): this was calculated by multiplying the perceived intensity (RPE) by the duration of the sessions or game (min). Workload was expressed in arbitrary units (AU).[19]

Statistical analysis

Time of exposure, rate of injuries, RPE and sRPE were recorded for 32 weeks. Data analysis was performed using the SPSS V.18.0 software for Windows (SPPS Science Inc., Chicago, IL, USA).

Initial descriptive analysis expressed through the minimum, maximum, mean and standard deviation of all variables was performed. Later, and after the data normality study a Pearson correlation was made with the numerical variables obtained during the data recording. An ANOVA one-way hypothesis contrast test was also performed to determine the difference between groups in relation to their susceptibility to injury. The average results of exposure time, injuries, RPE and workload (sRPE) were correlated using the Spearman Rho test with consideration of the sample size ($N = 11$). Finally, a lineal regression analysis was performed to determine the possible association between variables. In all cases the coefficient oscillated between −1 and +1, and the significance level established for all analyses was $p < .05$.

Results

Mean duration of training sessions in the mornings was 85.40 ± 16.07 min and in the evenings was 100.26 ± 18.71 min. The average RPE of the team after morning training was 3.5 ± 1.1 and after evening training was 6.0 ± 1.5 (Table 2).

A total of 83 injuries were recorded, 36 of which was classified in accordance to their diagnosis as muscular pain (S). Out of the total injuries 38 required the attention of the team physiotherapist (''Physio attention'' or FA) and 9 were considered time-loss (TL) injuries. The time-loss injuries were categorised in further detail depending on their severity. Two injuries were classified as ''minimal'' (1–3 days off sick), 3 as ''mild'' (4–7 days off sick), 2 as ''moderate'' (8–28 off sick) and 2 as ''severe'' (+ 28 days off sick). Thirty one injuries were recurrent and 16 were caused by contact with teammates and/or adversaries.

The side of the body with the most reported injuries was the right side with 29 injuries recorded. The most frequent location was the ankle (25), followed by the thigh (16) and the knee (10). With regards to injury type, 30 injuries were recorded in the form of cramps, 14 contusions and bruises and 8 sprains. The most significant cause of participating players' loss of activity (training or match) was sports injury.

During the study, 68 injuries occurred during training sessions and 15 during games.

The position which suffered the most time-lost injuries was the pivot with 7 episodes, followed by the small forwards with 2 recorded injuries.

Table 2 values (averages and SD) of the rate of perceived exertion (RPE) and training load by player during one season.

	RPE (CR-10)	Morning RPE (CR-10)	Evening RPE (CR-10)	LOAD (RPE × min)	Morning load (RPE × min)	Evening load (RPE × min)
Player 1	5.1 (±2.0)	3.3 (±.7)	5.8 (±1.4)	487.4 (±214.6)	270.6 (±90.1)	570.2 (±167.7)
Player 2	4.9 (±1.9)	3.5 (±1.2)	5.2 (±1.4)	483.9 (±194.9)	305.5 (±150.2)	518.1 (±159.9)
Player 3	5.8 (±1.8)	4.0 (±1.3)	5.9 (±1.6)	597.9 (±190.7)	351.3 (±144.0)	614.9 (±180.6)
Player 4	6.5 (±2.0)	3.9 (±1.0)	7.2 (±1.4)	639.1 (±203.3)	313.2 (±127.9)	725.7 (±162.2)
Player 5	5.4 (±2.0)	3.0 (±.9)	6.4 (±1.5)	530.8 (±204.5)	247.2 (±99.6)	642.9 (±162.0)
Player 6	6.3 (±2.5)	4.8 (±1.2)	7.0 (±.9)	615.6 (±263.3)	409.3 (±166.1)	709.8 (±134.2)
Player 7	6.2 (±2.2)	3.6 (±0.9)	7.3 (±1.4)	635.9 (±232.2)	307.3 (±112.2)	769.5 (±171.6)
Player 8	4.9 (±1.4)	2.8 (±.8)	5.0 (±1.4)	476.3 (±170.8)	274.2 (±107.5)	486.6 (±170.2)
Player 9	4.6 (±1.9)	3.1 (±.9)	5.1 (±1.3)	433.3 (±199.1)	246.2 (±77.4)	498.1 (±151.9)
Player 10	5.6 (±2.1)	4.0 (±1.3)	6.1 (±1.2)	547.2 (±201.9)	330.9 (±124.6)	612.2 (±132.4)
Player 11	4.4 (±1.5)	2.4 (±.6)	5.0 (±1.2)	422.9 (±145.1)	196.5 (±73.2)	486.0 (±118.4)
TOTAL	5.4 (±2.2)	3.5 (±1.1)	6.0 (±1.5)	533.7 (±224.3)	295.6 (±126.5)	603.1 (±175.3)

RPE: Average Rpe; morning RPE; Average of morning Rpe; Evening RPEe; Average of evening Rpe; Load: average load; Morning load: average morning load; Evening load: Average of evening load.

Table 3 Total training practices, games, hours of exposure and total number of injuries by player during one season.

	Number of training practices	Number of morning training practices	Number of evening training practices	Number of games	Total hours of exposure (h)	Hours of exposure to games (h)	Hours of exposure to training practices (h)	Hours of exposure to morning training practices (h)	Hours of exposure to evening training practices (h)	Number of injuries	Injuries (TL)	Injuries (FA)	Injuries (S)
Player 1	181	50	131	30	331	34	297	69	228	6	0	5	1
Player 2	112	18	94	20	215	29	186	26	161	7	2	0	5
Player 3	124	8	116	27	256	41	215	12	203	11	1	3	7
Player 4	162	34	128	30	311	40	271	48	223	12	0	4	8
Player 5	180	51	129	30	336	43	293	70	223	8	0	4	4
Player 6	134	42	92	22	256	30	226	62	164	9	4	4	1
Player 7	180	52	128	31	354	53	301	76	225	9	0	6	3
Player 8	124	6	118	28	244	31	213	10	202	9	2	1	6
Player 9	171	44	127	30	317	32	285	63	222	1	0	1	0
Player 10	143	33	110	28	278	39	239	49	190	7	0	7	0
Player 11	133	29	104	27	284	36	248	38	210	4	0	3	1
TOTAL	1644	367	1277	303	3182	408	2774	523	2251	83	9	38	36

Number of total training practices; number of morning training practices; number of evening training practices; number of games; total of exposure hours; total of game hours; hours of morning training practice exposure; hours of evening training practice exposure; total injuries; total time loss injuries; total physio attention injuries; total soreness injuries.

Table 4 Significant Spearman (Rho) correlations of training, games, exposure time and TL injury values.

Variable	Rho	*p*
Number of training practices	−.719*	.01
Number of morning training practices	−.560	.07
Number of evening training practices	−.646*	.03
Number of games	−.741**	.009
Total hours of exposure (h)	−.829**	.002
Hours of exposure to games (h)	−.634*	.03
Hours of exposure to training practices (h)	−.797**	.003
Hours of exposure to morning training practices (h)	−.560	.07
Hours of exposure to evening training practices (h)	−.745**	.009

Number of total training practices; number of morning training practices; number of evening training practices; number of games; total hours of exposure; total hours of games; hours of morning training practice exposure; hours of evening training practice exposure; significance level:
* $p < .05$.
** $p < .01$.

During the one-way ANOVA test differences were observed between the morning RPE ($F = 5.0811$; $p = .032$), the morning sRPE ($F = 7.3585$: $p = .010$) and the total time of exposure ($F = 3.5055$; $p = .064$) for the variables to get injured or not to get injured.

After performing the Spearman Rho test on the average results, highly significant negative ratios were observed between the number of training sessions and TL (rho = −.719; $p = .013$), matches played and TL (rho = −.741; $p = .009$) and hours of practice and TL (rho = −.797; $p = .003$) (Table 3).

From the lineal regression study a possible coincidence was observed between exposure time and TL which occurred during the study ($R^2 = .645$) (Table 4).

Discussion

The most important finding of this study is the association between exposure time and a reduction in the rate of time-loss injuries. This factor is related both to RPE and to sRPE of the morning training sessions.

During the season the players with the highest exposure to specific training load were the ones with the fewest setbacks in the form of injuries. The progressive increase of chronic load, assuming the adaption goals of the player, appears to show a protective effect regarding sports injuries in general and overuse in particular.[24] It is worth emphasising that during the study only 5 players did not suffer from any injuries which prevented them from training or competing. These data are consistent with previous research into women's professional basketball which confirm that the rate of injuries is even higher than in men's basketball.[25]

Despite the fact that other, previous studies have analysed the number of injuries imposed by excessive training loads on sportspeople,[14,26] appropriate management of training loads and of exposure time appears to reduce risk of injury.[27] Current recommendations derived from scientific evidence are that, pre-season, exposure time of players to the sports activity should be progressively increased and with heightened progression.[28]

However, an appropriate management of the training load is a relevant element in any phase of the season.[27,29] Chronic loads with an undemanding profile also have a negative effect, increasing the risk of injury. The findings in this study are consistent with this last statement, observing that players with the highest exposure time were those who suffered from the fewest TL injuries ($p = .003$). The highest load demands imposed on sportspeople were appropriately controlled and were individually treated.[30]

During the study 9 time-loss injuries were recorded, 2 of which were severe, with the player having more than one month of sick leave. The most recurrent severity level in the study was that of ''slight'', with many situations requiring the attention of the physiotherapist but without causing any absence from sessions (74 occasions). This fact which is highly common in professional sport must be known so as to interpret the statistical analysis correctly. Injury in professional sports is an extremely multifactorial dimension which may be influenced by a myriad of factors[31] and often the sportsperson's interest in not missing out on any activity time despite feeling discomfort does not help to properly detect the relationship between internal and external risk factors and the events which may trigger more serious subsequent injuries.[32]

Recovery time between training and competitions is another relevant aspect that deserves examination. Optimum recovery may reduce the risk of injury.[33] The literature affirms that sportspeople become injured for four main reasons: over training, over-powered, lack of preparation and lack of recovery.[34,35]

With regard to the results obtained in this research study, it can be confirmed that the morning RPE ($p = .032$) and the morning sRPE ($p = .01$) impacted the occurrence of an injury. In the team studied, the evening training sessions finished at eleven at night and the players attended training at ten in the morning. The fact that there was not sufficient a margin of recovery time is an aspect that should be assessed and managed appropriately as a preventative measure. Optimum rest is not only a beneficial variable for sportspeople's health, it also allows the players to reach their maximum athletic performance,[36] which leads us to believe that in highly competitive sports recovery is one of the most important elements of a training regime.[37]

Table 5 Results of the simple lineal regression analysis that explains the TL injuries in accordance with time of exposure to training practice.

Summary of regression model				
Model	R	R^2	Adjusted R^2	RMSE
1	80	65	60	84

ANOVA of the equation

Model		Sum of squares	df	Mean of squares	F	p
1	Regression	11.37	1	11.37	16.32	003
	Residual	6.27	9	.69		
	Total	17.36	10			

Coefficients of the equation

Model		Not standardised	Standard Error	Standardised	t	p
1	(Constant)	9.22	2.27		4.37	.002
	Time of exposure to training practice	−.04	.11	−.80	−4.04	.003

Predictive variable: time of exposure to training practices.
Dependent variable: TL injuries.

In this study, exposure time of each player was analysed to avoid interpretation of results that could be biased by the number of training sessions. This is one of the major limitations of the study, since a player who is off sick could not participate in the training sessions. Being aware of exposure time, meant that this time could be related to injury in a clearer fashion and therefore the values of each player were able to be recorded individually and their exposure was modified whenever something from the established plan varied. We also took into account the players who contested games with their national selection, when their exposure time was therefore affected. Some specific examples from the sample are that player 7 presented with a total of 354 exposure hours and during that time suffered from no injuries that caused them to be off sick. Player 9 played for a total of 318 h and did not suffer from any serious injury either. However, other players who had less exposure hours, as was the case of player 2 (215 h) and 8 (244 h) suffered in both cases from 2 time-loss injuries (Table 5).

Practical application

When planning the season all variables which could affect a sports injury occurring should be taken into consideration. Useful and ecological control and assessment tools should be incorporated which simultaneously enable correct monitoring of the sessions.

It is vital to encourage optimum recovery, controlling times when training sessions commence, or improving travel management. Lack of rest may lead to a negative effect in the training process and may foment injuries.

Identifying players with a lower training load and giving them personalised complementary tasks should be a basic element for the prevention of injuries.

Conclusions

The indicators suggest that increasing exposure time to specific training could reduce the risk of time-loss injuries occurring.

RPE is profiled as a useful, valid and ecological tool for managing training load in professional women's basketball.

Future outlook

Sport needs applied science to continue improving.[38] Understanding the effect of training in the development of the sportsperson, and management of optimum loads will allow us to continue advancing in the field of performance optimisation and the prevention of injuries.[39] At present there are several models which enable this monitoring to take place and which may be useful in contexts like this study.

Study limitations

This study only includes one sport season and a sample of 11 players. The morning training sessions impacts the values reported during the evening session.[40] This aspect should be taken into consideration if decisions are taken using these subjective indicators.

A period of familiarisation with the players is always necessary with the RPE scale, since the highly significant variations in the values given by sportspeople may give rise to erroneous conclusions during their analysis.

Conflict of interests

The authors have no conflict of interests to declare.

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