Preventing injuries using a pre-training administered rated perceived exertion scale

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Summary

The objective of this study was to develop an injury prevention protocol based on Rated Perceived Exertion (RPE) before and after training sessions was measured using the CR-10 Borg scale. Measuring pre-training exertion allows players to inform their coach about their state before initiating any activity, which helps the coach to adjust the training load. A total of 12 players from the Spanish first-division "Hormigoneras Umacón" futsal team were followed-up during the 2013/2014 season. Data were collected for 40 weeks in 225 training sessions. The injuries sustained and pre-training RPE obtained were recorded for each player. A RPE value of "6" was considered a "warning sign" that indicated that the player might not be in optimal conditions to support the planned training load. The results reveal that the incidence of injuries was lower ($p<0,05$) among the players showing a lower number of warning signs. In addition, in the months with a higher training volume, warning signs were useful in reducing the number of injuries sustained by the players. In conclusion, "warning signs" indicate alterations in the physical state of players before initiating any activity, which allows the coach to modify the training load and reduce the risk of injuries.

Key words:
Futsal. Training load. Prevention of injuries. Subjective perception.

Prevención de lesiones usando la escala de percepción subjetiva del esfuerzo

Resumen

El objeto de estudio fue desarrollar un protocolo de prevención de lesiones basado en la Percepción Subjetiva de la Fatiga antes del entrenamiento. De acuerdo con autores que utilizan la Percepción Subjetiva (RPE) mediante la Escala CR-10 de Borg para evaluar la fatiga del jugador antes y después del entrenamiento, analizamos la fatiga previa considerando que esta variable permite al deportista informar al entrenador de sus sensaciones antes de iniciar la actividad, posibilitando variar las cargas. Participaron 12 jugadores del equipo "Hormigoneras Umacón" de Primera División española de fútbol sala durante la temporada 2013/2014. Se recogieron datos durante 40 semanas en 225 sesiones de entrenamiento. Se registraron las lesiones producidas y los valores de Percepción Subjetiva de la Fatiga previa de cada jugador estableciendo que un RPE de 6, denominado "señal de alerta", mostraba condiciones no óptimas para soportar las cargas planificadas. Los resultados muestran que los jugadores que menor número de señales tuvieron fueron los que mayor incidencia lesional reflejaron y viceversa ($p<0,05$). Además en los meses con mayor volumen de entrenamiento se consiguió que el número de lesiones no fuese mayor que el resto gracias a las señales de alerta obtenidas. Concluimos que la "señal de alerta" informa de cualquier alteración del estado del deportista antes de iniciar la actividad permitiendo modificar la carga disminuyendo el riesgo de lesión.

Palabras clave:
Fútbol sala. Carga de entrenamiento. Prevención de lesiones. Percepción subjetiva.

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Introduction

In any sport and, specifically, in team sports, one of the most common causes of athletes' poor adaptation is the lack of communication with the coach[1]. Mutual athlete-coach trust and open communication allow the coach to assess the state of the athlete and avoid athlete's exposure to high-risk situations for their physical and mental state. As a consequence it is necessary that players and athletes get involved in the control of the training loads and the data provided to the coach are crucial in designing an individualized and successful training plan[1].

One of the main qualitative methods used in the control of training is Rated Perceived Exertion (RPE)[2] defined by Borg en late 1982[3] as "an individual's rating of exercise intensity or the level of exertion experienced by the athlete".

Fóster *et al.* (2001)[4] suggestet that overall RPE allows to quantify exercise intensity and make calculations using a single number that represents the combined intensity of each of the drills included in the training session. Foster this reason, Foster stated that RPE is a simple and valid method for team sports.

Most studies on team and individual sports used overall RPE to control and assess the intensity of the effort made by the athletes[5-11]. However, other authors[12, 13] used measured RPE using the CR-10 scale[14] to gauge athlete's perceived exertion before and after the training session, and also to collect information useful to injury prevention before the training session is useful in collecting full information on the physical and mental state of the athlete in order to prevent injuries[12,13]. Player's feedback will be useful for the coach to assess the impact of previous training loads and evaluate player's state before initiating the training session. The coach compares the information provided by the player with his own observations made throughout the training process and with the planned training load values, which will allow him to adjust the training plan, as necessary. In this way, the object of the Study is to use perceived exertion prior to the training session (pre-training RPE) to detect improper adaptation to previous training loads and prevent injuries.

Material and method

Study design

An observational, longitudinal, repeated-measures, 40-week study including 225 training sessions in the 2013-2014 season.

Participants

The study included players from the first team of "Hormigoneras Umacón Zaragoza" of the Spanish First Divison Futsal League (n=12).

The methods employed were approved by the Ethics Committee of the University of Zaragoza, Spain, according to the guidelines of the Declaration of Helsinki regarding human experimentation, which was approved in 1974 and modified in 2008. Informed consent from all players was obtained. Participants were free to withdraw from the study at any time.

Characteristics of the sample

Age 27.00±5.12 years; height 1.75±0.05 m; weight 73.97±6.13 kg.

Inclusion criteria

Being a player of the first team or the youth team and attending training sessions every day.

Exclusion criteria

Not attending training sessions every day, having long-duration injuries (more than two months) and not having completed half of the season (twenty weeks).

Data Collect

We developed a method to inform the coaching team about player's risk of injury before the training session, so that they could adjust the training load at individual or collective level. For this purpose, we established a RPE threshold value that indicated to the coaching team that the state of the player was compromised. Due to the scant literature available on pre-training RPE, we used the values obtained in a pilot study carried out during the 2012-2013 season with 13 players (age 26.34±4.11 years; height 1.82±0.09 m; weight 71.77±6.86 kg.) along with those reported by Del Campo (2004)[12], which followed-up 10 basketball teams over 21 training sessions. In our pilot study, the mean RPE value obtained was 5.36±1.30, and was 4.89±1.12 for the Del Campo study. Basing on these data, we established that a player reporting a pre-training RPE value exceeding 6 –which corresponds to a feeling of "exertion" in the CR-10 scale– without any apparent reason is not in the optimal condition to bear the planned training load, which is considered a "warning signal". This value of 6 is above the means obtained in both studies, which is why we considered that it was a value from which the player could suffer a poor adaptation to the training loads and suffer risk of injury.

- Daily log of RPE as measured using the *CR-10 scale* (Figure 1) to assess player's level of exertion before initiating the training session. The physiotherapist and the players recorded player's physical and mental state. The physical trainer would distribute the individual registration form to each player before starting the training and verify that all will register correctly.
- The following variables were also measured: duration of training (in minutes), missed training time, injuries sustained and training sessions missed due to injury. Injury data were recorded according to the guidelines of the Injury Consensus Group through the Fédération Internationale de Football Association Medical Assessment and Research Centre (F-MARC)[15]. This way, we could compare the results obtained with those reported in other studies that used the same methodology[16-20]. Injury is understood as physical injury resulting from sports during a match or training regardless of having to receive medical attention or loss of training or match time[16]. The team doctor was the person in charge of recording and analyzing all the injuries produced.

Figure 1. CR-10 Scale.

CR-10 Scale	
Well-rested	1
	2
Rested	3
Little tired	4
	5
Tired	6
Pretty tired	7
Very tired	8
Exhausted	9
	10

Analysis of pre-training RPE

Since a warning sign is a subjective indicator, we analyzed them from three perspectives:

- Difference between normal and unusual exertion;
- Differences in players' response;
- Detection of warning signs.

Difference between normal and unusual exertion

Player's perception of pain, discomfort or hard exertion was essential for warning signals to be effective in preventing a potential injury. It was necessary that the player could distinguish between normal exertion during the training process and other unusual negative feelings. It is crucial that players learn to listen to their body in order to minimize potential injuries[21]. Therefore, it was very important to help players learn to distinguish between the pain and "normal" discomfort caused by regular training and the pain caused by an injury.

Thus, we achieved that players recorded perceived exertion consciously. Players adapted to this change and started to devote some time to reflect on and record their training routine. This way, players learned to know themselves better and understand the response of their body to different training modalities. The RPE scale became a sports educative instrument for players.

Differences in players' response

The experience and knowledge the coaching team had of the players were essential to identify differences in perceived exertion rates. Weinberg and Gould (1999)[22] highlighted the relevant role of the coaching team and, more specifically, the role of coaches in the incidence of injuries, since it is the coach who determines the time devoted by each player to play and rest. In this study we observed that as the season progressed coaches progressively knew the players better. This allowed them to analyze the RPE of each player differently according to their characteristics so that their response could be analyzed individually.

Detection of warning signs

Warning signs were analyzed according to the previous, planned and pursued training drills. It was not a serious problem when a player showed a warning sign during a regenerative session, since the planned drills for that session were intended to accelerate players' recovery and were beneficial to them. The preseason after the holidays involves a hard training process aimed at making players attain an optimal fitness state. Thus, some of the warning signs identified during the preseason may have been expected by the coaching team, who had foreseen and assumed the risk of injury[23].

Once the warning sign was detected, we tried to identify the cause. The rate reported by the player, their observations and the reports prepared by the physiotherapist before the training session provided the coaching team with complementary information that helped them to find the causes of the warning sign. According to the criteria established by García *et al.* (1996)[20], the most common causes of warning signs were:

- Fast increase in the training load;
- Insufficient time for recovery between sessions;
- Social and affective conflicts;
- Toxic, sexual and dietary excesses;
- Psychic disturbances;
- Illness.

When hard exertion was caused by psychological factors, the player received moral support from the coach, who listened to them sympathetically. Extreme cases such as depression and associated disorders were not reported. Such a case would have required the intervention of the medical staff. Poorly controlled, stressing psychological problems derived from family conflicts, disputes with team mates or relationship problems may increase the risk of injury[23] although they cannot cause an injury directly[15,22]. We agree with these authors that mutual player-coach trust and open communication allow the coach to evaluate the state of the player and avoid player's exposure to situations that are deleterious for their physical and mental state.

When the cause of hard exertion was physical, in most cases the reason was that the player had not assimilated the efforts made. In theses cases, the coaching team adjusted training intensity and/or volume or modified the drills included in training sessions. According to Anderson *et al*. (2003)[21] "altering or modifying training programs may be the response to reducing player's susceptibility to injuries." Piggot (2008)[23] used a similar methodology with Australian football players. Thus, once the risks of injury had been identified, the coaching team modified the training program. Piggot affirmed that if an early intervention had not been made, the incidence of injuries would probably have been higher. This statement supports our hypothesis that adjusting training plans before they are initiated is effective in preventing injuries. The measures adopted were:

- Reducing training volume and/or intensity;
- Modifying or removing specific drills and/or actions;

Table 1. Warning signs, injuries, missed sessions and injury incidence for each player.

Player	Warning signs	%Warning signs	Injuries	Missed sessions	Volume (hours)	Injury incidence
8	43	36.75%	2	2	372.17	5.37
3	22	18.81%	4	5	377.43	10.60
7	20	17.09%	2	3	383.98	5.21
10	14	12.00%	2	5	250.08	8.00
1	6	5.12%	3	14	350.30	8.56
5	4	3.41%	0	0	357.85	0.00
6	4	3.41%	1	2	385.47	2.59
2	2	1.71%	4	11	363.17	11.01
11	2	1.71%	0	0	297.18	0.00
12	2	1.71%	0	0	283.25	0.00
4	1	0.85%	4	16	357.88	11.18
9	1	0.85%	4	4	318.38	12.56
Team	117	100%	26	62	4.097.15	

- Increasing rest periods during the training session;
- Respecting the healing process of injuries before resuming training with the team;
- Introducing preventive programs to strengthen individual weaknesses.

Statistical analysis

Descriptive and inferential statistical analysis of the different variables was performed using the SPS, version 19, software package (License property of the University of Zaragoza) and Excel.

- The descriptive statistical analysis was performed using mean values and standard deviation for quantitative variables, and percentages for qualitative variables.
- We calculated the point-biserial correlation coefficient to assess the correlation between a quantitative variable (number of injuries) and a dichotomous variable (the team's pre-training RPE)(r_{bp}).

Results

We observed that the players who showed a higher number of warning signs (players 3, 7 and 8) missed few training sessions and minutes of training. However, when comparing the number of warning signs and the incidence of injuries, we found that players 4 and 9 –who only showed one warning sign– were the players who sustained the highest number of injuries (Table 1).

The following values were noticeable:

- Player 8: 43 warning signs, 2 injuries, 2 training sessions not completed.
- Player 4: 1 warning sign, 4 injuries, and 2 training sessions and 1,320 minutes missed.

In August, the volume of minutes missed was 3,990, a total of 55 warning signs were observed, three injuries were recorded and the incidence of injuries was 3.7 injuries/1,000h. From September, the training volume decreased and was maintained constant throughout the season. In September, the number of warning signs decreased to 26. Nevertheless, this figure is higher than in the other months. Conversely, the number of injuries was maintained. April was the month with the highest number of injuries: 4; while December and March were the months with the lowest number of injuries: 1 (Table 2).

Table 2. Warning signs, injuries and injury incidence of each month.

Month	Warning signs	Injuries	Volume	Injury Incidence
August	55	3	3.990	3.76
September	26	3	2.860	5.24
October	8	3	2.600	5.77
November	9	3	2.605	5.76
December	3	1	2.640	1.89
January	7	3	1.675	8.96
February	4	3	2.920	5.14
March	4	1	2.180	2.29
April	1	4	2.255	8.87
May	0	2	2.185	4.57
Total	117	26	24.665	5.57

At the end of the season, to examine if there was a correlation between pre-training RPE and the number of injuries, we used a biserial correlation formula, considering that there were no injuries in 21 weeks, and injuries were detected in 19 weeks. There were no significant differences between means (r=0.09), which shows that a higher RPE did not involve a higher number of injuries (Table 3).

Table 3. PSF previous relationship - number of injuries.

Average perceived fatigue in weeks = 0 injuries	**3.20**
Average perceived fatigue in weeks ≠ 0 injuries	3.29
Standard desviation perceived fatigue	0.50
% weeks = 0 injuries	0.52 (21 weeks)
% weeks ≠ 0 injuries	0.48 (19 weeks)
Point biserial corelation = 0.09	

Discussion

Identifying warning signs, sessions missed due to injury and the incidence of injuries during the season

We observed that the players who showed a higher number of warning signs (Table 1) missed few training sessions and minutes of training. Conversely, the players who showed a lower number of warning signs were the ones with a higher incidence of injuries. We concluded that warning signs were a useful indicator of the risk of injury, which helped the coaching team to prevent them. Players were trained in the identification of warning signs. The results obtained in this study are consistent with those of Piggot (2008)[23]. In his 15-week study of an Australian football team Piggot concluded that the low number of injuries (only five) was due to the intervention of the coaching and the medical team. These teams identified any potential risk factor for player's health before initiating the training session.

Warning signs and incidence of injuries by months

The results displayed in Table 2 show a direct relationship between training volume and the number of warning signs. However, the number and incidence of injuries were not higher as compared to the other months. This situation was especially evident in August and September, the two months with the highest training volume. This period coincided with the preseason, where the training volume was higher, since the cumulative effect of all the previous sessions over the past weeks increased the risk of injury. This conclusion is in agreement with that of Anderson *et al.* (2003)[21], who studied a III-division female basketball team of the NCAA and observed that the risk of injury was higher during the first weeks of the season and gradually decreased as the season progressed as a result of players' adaptation. Milanez *et al.* (2014)[24] followed-up a professional female football team for five weeks. They reduced the training volume by 45% during the season with respect to the preseason and concluded that this was one of the main causes of the higher number of injuries sustained in the first weeks of training. Piggott (2008)[23] stated that 40% of injuries could be due to the increase in the training load. Gabbett and Domrow (2007)[25] observed that in contact sports, there was a correlation between the likelihood of sustaining an injury and the training load, especially during the preseason. In his study on semi-professional rugby players, Gabbett (2004)[26] found that the incidence of injuries in training sessions was strongly correlated (r=0.86) with the training load.

In August, although the risk of injury was much higher –as the significant number of warning signs show–, the number of injuries was low, which confirms that warning signs helped to reduce the number of injuries during the preseason. Conversely, it is to be noticed that April was the month with the lowest number of warning signs –only one– and with the highest number of injuries.

As regards the incidence of injuries, we highlight the difference between the value obtained for April (8.87inj./1,000h) despite the fact that only one warning sign was identified, and the value for August (3.76inj./1,000h) where 55 warning signs were detected. These results demonstrate that it is crucial that players learn to identify warning signs correctly in order to inform the coaching team about their state and prevent injuries.

Correlation between pre-training RPE and the incidence of injuries

The correlation value obtained between previous RPE and the number of injuries (r=0.09) demonstrates that a higher pre-training RPE does not involve a higher number of injuries (Table 3). These results are logical, since according to Anderson *et al.* (2003)[21], as soon as a warning sign is identified, training loads are adjusted to prevent injuries. This demonstrates the efficacy of the methodology employed in our study. The results obtained indicate that the threshold value of "6" established as a warning sign is a valid indicator of risk of injury.

The measures adopted were based on two key factors for team performance: the player's state of mind and their physical condition. According to the literature available, most injury prevention plans are aimed at correcting specific aspects such as postural changes, low force work levels or imbalance between time of exposure and rest periods[27,28]. However, these authors do not take into account that these factors do not operate individually but rather in complex interaction[17]. On the other hand, according to this author, prevention plans should not be evaluated only through experimental randomized, control-group studies, but also using more rigorous, semi-experimental studies including a more representative sample such as a team of professional athletes, and be performed in more realistic environments. Using pre-training RPE and warning signs allowed us to evaluate all these factors comprehensively and prevent injuries.

Despite the results obtained, we cannot ensure that they would have been different if we had not used RPE, since it would have been necessary to compare them with a control group[28]. However, this was not feasible for a professional team, where results are of paramount importance. Nevertheless, we could compare our results with those obtained by our research team in the 2004/2005 season[16], where the RPE scale was not used but the data collection methodology, the characteristics of the study population, the sports level and training methods used were the same, which is essential for both studies to be comparable[18]. In the 2013/2014 season there was a very significant reduction in the incidence of injuries with respect to the 2004/2005 season, which was 5.27inj./1,000h and 19.72inj./1,000h, respectively. This indicated that pre-training RPE can be used as an injury prevention measure.

Conclusions

- The use of a daily log requires some training of coaching teams and players.
- Pre-training RPE allows:
  - The use of warning signs indicating alterations in the state of the player before initiating any activity.
  - The modification of the training load and subsequent reduction in the risk of injuries.
- The methodology based on the identification of warning signs obtained using pre-training RPE for the prevention of injuries allowed us to reduce the incidence of injuries with respect to the previous season, which had similar characteristics.
- This study opens new lines of research and proposes viable injury prevention measures that can be included in the planning of training loads in team sports and will improve collective and individual performance.

Bibliography

1. Ahern DK, Lohr BA. Psychosocial factors in sports injury rehabilitation. *Clin Sports Med.* 1997;16:755-68.
2. Hopkins WG. Quantification of training in competitive sports, methods and applications. *Sports Med.* 1991;12(3):161-83.
3. Borg G. A category scale with ratio properties for intermodal and interindividual comparisons. En: Geissler HG, Petzold P. *Psychophysical judgment and the process of perception*. Hamburg: Collection Deutscher Verlag der Wissenschaften; 1982. p. 25-34.
4. Foster C, Heimann KM, Esten PL, Brice G, Porcari JP. Differences in Perceptions of Training by Coaches and Athletes. *Sports Med.* 2001;8:3-7.
5. Borresen J, Lambert MI. Quantifying training load: A comparison of subjective and objective methods. *Int J Sports Physiol Perform.* 208;3(1):16-30.
6. Alexiou H, Coutts AJ. A comparison of methods used for quantifying internal training load in women soccer players. *Int J Sports Physiol Perform*. 2008;3(3):320-30.
7. Green JM, McIntosh JR, Hornsby J, Timme L, Gover L, Mayes JL. Effect of exercise duration on session RPE at an individualized constant workload. *J App Physiol.* 2009;107 (5):501-7.
8. Little T, Williams AG. Measures of exercise intensity during soccer training drills with proiessional soccer players. *J Strength Cond Res.* 2007;21(2):367-71.
9. Hill-Haas SV, Rowsell GJ, Dawson BT, Coutts AJ. Acute physiological responses and time-motion characteristics of two small-sided training regimes in youth soccer players. *J Strength Cond Res.* 2009; 23(1):111-5.
10. Buchheit M, Lepretre PM, Behaegel AL, Millet GP, Cuvelier G, Ahmaidi S. Cardiorespiratory responses during running and sport-specific exercises in hadball players. *J Sci Med Sport.* 2009;12(3):399-405.
11. Manzi V, D`Ottavío S, Impellizzeri FM, Chaouachí A, Chamarí K, Castagna C. Profile of weekly training load in elite male professional basketball players. *J Strength Cond Res.* 2010;24(5):1399-406.
12. Del Campo J. *La intensidad del entrenamiento en jugadores de baloncesto medida a través de la percepción de esfuerzo y fatiga.* Tesis doctoral, Universidad de Madrid, Madrid. 2004;102-98.
13. Drobnic F, Puigdellívol T, Bové T. *Bases científicas para la salud y un óptimo rendimiento en baloncesto.* Madrid. Editorial Ergon; 2009. p. 30-2.
14. Borg G. A simple rating scale for use in physical work test. *Fysio Sdllsk Lund Forhan.* 1962;32:7-15.
15. Fuller CW, Ekstrand J, Junge A, Andersen TE, Bahr R, Dvorak J. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40:193-201.
16. Álvarez J, Manonelles P, Giménez L, Nuviala A. Incidencia lesional y su repercusión en la planificación del entrenamiento en fútbol sala. *Arch Med Deporte.* 2009;26(4):261-72.
17. Noya S, Manuel S. Epidemiología de las lesiones en el fútbol profesional español en la temporada 2008-2009. *Arch Med Deporte.* 2012;150(4):750-66.
18. Gould D and Udry E. *Psychology of knee injuries. En: Griffin L. Rehabilitation of the injuried knee.* Chicago: Collection Mosby Year Book; 1995. p. 86-98.
19. Ekstrand J, Walden M, Hagglund M. A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup. *Br J Sports Med.* 2004;38(4):493-7.
20. García JM, Navarro J, Ruiz JA. *Bases teóricas del entrenamiento deportivo. Principios y aplicaciones.* Madrid. Editorial Gymnos; 1996. p. 87-92.
21. Anderson L, Triplett-McBride T, Foster C, Doberstein S, Brice G. Impact of training patterns on incidence of illness and injury during a women`s collegiate basketball season. *J Strength Cond Res.* 2003;17(4):734-8.
22. Weinberg RS, Gould D. *Foundations of Sport and Exercise Psychology.* Champaign. Editorial Human Kinetics; 1999. p. 23-8.
23. Piggott B. The relationship between training load and incidence of injury and illness over a pre-season at an Australian Football League Club. Tesis Doctoral, Cowan University, Joondalup. 2008;100-23.
24. Milanez V, Ramos S, Okuno N, Boullosa D, Nakamura F. Evidence of Non-Linear Dose-Response Relationship between Training Load and Stress Markers in Elite Female Futsal Players. *J Sport Sci Med.* 2014;13:2-29
25. Gabbett, TJ, Domrow N. Relationships between training load, injury, and fitness in sub-elite collision sport athletes. *J Sports Sci.* 2007;8:1-13.
26. Gabbett TJ. Reductions in pre-season training loads reduce injury rates in rugby league players. *Br J Sports Med.* 2004;38:743-9.
27. Van Tiggelen D, Wickes S, Stevens V, Roosen P, Witvrouw E. Effective prevention of sports injuries: a model integrating efficacy, efficiency, compliance and risk-taking behaviour. *Br J Sports Med.* 2008;42:648-52.
28. Dvorak J, Junge A, Chomiak J, Graf-Baumann T, Peterson L, Rosch D. Risk factor analysis of injuries in football players. Possibilities for a prevention program. *Am J Sports Med.* 2000;28(5):69-74.