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Recovery–stress balance and injury risk in professional football players: a prospective study

PHILIPP LAUX[1], BERTRAM KRUMM[2], MARTIN DIERS[1] & HERTA FLOR[1]

[1]*Department of Cognitive and Clinical Neuroscience, Central Institute of Mental Health, Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany and* [2]*Department of Biostatistics, Central Institute of Mental Health, Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany*

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Abstract
Professional football is a contact sport with a high risk of injury. This study was designed to examine the contribution of stress and recovery variables as assessed with the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) to the risk of injury in professional football players. In a prospective, non-experimental cohort design, 22 professional football players in the highest German football league were observed over the course of 16 months. From January 2010 until April 2011, the players completed the RESTQ-Sport a total of 222 times in monthly intervals. In addition, injury data were assessed by the medical staff of the club. Overall, 34 traumatic injuries and 10 overuse injuries occurred. Most of the injuries were located in the lower limb (79.5%), and muscle and tendon injuries (43.2%) were the most frequently occurring injury type. In a generalised linear model, the stress-related scales Fatigue (OR 1.70, $P = 0.007$), Disturbed Breaks (OR 1.84, $P = 0.047$) and Injury (OR 1.77, $P < 0.001$) and the recovery-related scale Sleep Quality (OR 0.53, $P = 0.010$) significantly predicted injuries in the month after the assessment. These results support the importance of frequent monitoring of recovery and stress parameters to lower the risk of injuries in professional football.

Keywords: *recovery, stress, injury risk, professional football, soccer*

Introduction

In professional football, the risk of injuries is high. Intensive games, travelling, unfamiliar sleeping surroundings, interruption of circadian rhythms and a short regeneration phase add to high physical and psychological pressures (Dupont et al., 2010; Ekstrand, Waldén, & Hägglund, 2004; Meyer, Kellmann, Ferrauti, Pfeiffer, & Faude, 2013; Nédélec et al., 2012). Although there is a sizeable number of studies on the relationship of stress and injury in sports (for a summary, see Williams & Andersen, 2007), there are few studies on the relationship of stress and injuries in professional football players. Many of these studies were performed in young elite football players (e.g. Brink et al., 2010; Dvorak & Junge, 2000; Junge, Cheung, Edwards, & Dvorak, 2004; Kucera, Marshall, Kirkendall, Marchak, & Garrett, 2005; Le Gall et al., 2006; Price, Hawkins, Hulse, & Hodson, 2004). In professional football, the Union of European Football Associations (UEFA) initiated a scientific project with the goal to minimise the number of injuries and to optimise work-related safety for professional football players (Hägglund, Waldén, Bahr, & Ekstrand, 2005; Hägglund et al., 2013). Injuries not only greatly impact on the performance of a player and the team (Ekstrand, 2013) but also cause immense monetary losses (Hallén & Ekstrand, 2014).

For the prevention of injuries, it would be important to know which physical or psychological factors are associated with them. Gajhede-Knudsen, Ekstrand, Magnusson, and Maffulli (2013) investigated the renewed appearance of Achilles tendon injuries over a time period of 11 years in the UEFA Champions League. They found a close connection between a previous and a current Achilles tendon injury and the risk of a renewed injury was higher after short recovery phases. Kristenson, Waldén, Ekstrand, and Hägglund (2013) pointed to a lower risk of injuries in newcomers (first year as a profes-

Correspondence: Herta Flor, Department of Cognitive and Clinical Neuroscience, Central Institute of Mental Health, Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany. E-mail: herta.flor@zi-mannheim.de

sional football player); however, they showed a higher number of stress fractures. Ekstrand and Van Dijk (2013) reported that fractures in the fifth metatarsal are significantly more frequent in younger players during the preseason with high-intensity training load. Psychological factors are increasingly investigated in professional football players, in line with many studies in other sports (cf. Johnson, Tranaeus, & Ivarsson, 2014; Williams & Andersen, 2007). Johnson and Ivarsson (2011) reported that stressful life events, somatic trait anxiety, mistrust and ineffective stress coping all contributed to higher injury risk in young elite football players. These stressors and the reaction of the athlete to a potentially stressful athletic situation are thought to determine whether injury will ensue as summarised by Williams and Andersen (1998) in their theoretical model of psychosocial and stress-related determinants of injury in sports. Several potential stressors such as aversive life events, previous injuries, many daily hassles or a too short recovery time may influence injury risk (Williams & Andersen, 2007).

Bengtsson, Ekstrand, and Hägglund (2013) showed that short football-related recovery periods (less than 4 days) increased the number of hamstring and quadriceps injuries compared to longer recovery periods (6 or more days) before the next game. These results were supported by Dupont et al. (2010). The injury rate was significantly higher for players who played two matches per week compared to one match per week. Ryynänen et al. (2013) reported that the number of injuries was significantly higher within the time or during a 5 min period after a special event such as red or yellow cards, goals or injuries of other players. They suggest that these events lead to a break of the normal course of the game that influences the strategic and psychological level of the players and the teams. This changed concentration and awareness may lead to increased injury risk, although these breaks could also be a chance to refocus and reduce injury risk. These objective measures of recovery between and within games can be complemented with subjective measures of perceived stress and recovery.

One measure that has been developed to assess the athletes' perception of the balance between stress and recovery phases is the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (Kellmann & Kallus, 2000, 2001; Meyer et al., 2013). This measure was designed based on the assumption that a culmination of stress factors in various areas of life leads to a maladaptive psychophysical state if there is no sufficient possibility of recovery in line with the previously established stress and injury model (Williams & Andersen, 1998, 2007). The RESTQ-Sport inventory consists of general and sport-specific stress and recovery scales. Brink et al. (2010) monitored the recovery and stress balance using the RESTQ-Sport in young elite football players in a prospective longitudinal cohort design and examined the relationship to injuries and illnesses. The scale Injury, which assesses if the muscles of the athlete feel stiff or tense or if the athlete feels vulnerable to injuries, was significantly higher for players with traumatic and overuse injuries compared to healthy players. Ill players showed significantly more general stress. The scales Emotional Stress, Social Stress, Conflicts/Pressure, Fatigue, Lack of Energy and Physical Complaints were significantly higher in this group compared to healthy players. Furthermore, ill players reported significantly less Social Recovery, General Well-Being and Sleep Quality. On the sport-specific scales, the ill players showed significantly more Disturbed Breaks, Emotional Exhaustion, Injury and significantly less Being in Shape. Studies about the relationship of the psychophysical recovery–stress balance and injuries in the professional football in the top leagues are lacking.

This study was designed to examine the contribution of stress and recovery variables as assessed with the RESTQ-Sport to the risk of injury. We hypothesised that high stress and low recovery values in the recovery- and stress-related scales would increase the risk of a later injury. We used a longitudinal design where the players completed the RESTQ-Sport once a month and injuries in the subsequent month were predicted.

Methods

Participants

We used a prospective non-experimental cohort design to assess 22 professional football players in the highest German football league. The size of the team was 26 players in the 2009/10 season and 25 players in 2010/11. In the season 2010/11, six players, and in the season 2011/12, three players refused to participate. A total of 18 field players participated over the entire 16-month assessment period, 3 players participated over 11 months and 1 player over 5 months. Thus data from 22 players could be used for the study. The sample was limited to this number since only professional players of one Bundesliga team, where both players and the management supported the study, could be included. The mean age of the players was 25.8 ± 5 years, all were male. The number of matches, including national (First German Division, 1st Bundesliga and Cup Matches, DFB-Pokal) and international matches (Champions League) over the course of 16 months was 74. Friendly matches were not included.

The players as well as the participating club signed informed consent permitting the use of the RESTQ-Sport and injury data in anonymous versions. The ethics committee of the Medical Faculty Mannheim, Heidelberg University, approved the study, which adhered to the Declaration of Helsinki.

Assessment of the injury data

The injury data were collected from January 2010 until May 2011 covering 16 months excluding the summer break. The documentation of injuries and illnesses was performed by the medical staff of the football club. An injury was defined as: the injury occurred during a football match or during training and led to an absence of the next training session or match (time loss injury). The player counted as injured until the medical staff approved participation in the training or a match (Fuller et al., 2006; Hägglund et al., 2005). Traumatic injuries were defined as injuries, which came suddenly with a known reason. Injuries due to overuse were defined as injuries due to micro-trauma and without a known reason (Fuller et al., 2006). The location, type, mechanism and the severity of the injuries were documented. According to Fuller et al. (2006), the severity of the injuries was classified in degrees dependent on the days of absence of the players from team training or match plays: 1–3 days (minimal injuries), 4–7 days (mild injuries), 8–28 days (moderate injuries) and >28 days (severe injuries). Absence due to illnesses such as fever, nausea or infections was documented as well.

Assessment of stress and recovery

The RESTQ-Sport was administered monthly from January 2010 until April 2011 to assess the current recovery–stress balance of the players. The RESTQ-Sport was always completed 2 days before the first national league match in the month on the weekend independent of the number of matches per week. The players completed the questionnaire online before the training session. The time of the assessment varied according to the training schedule. In the morning session, it was between 08:30 am and 09:30 am, in the midday session between 02:00 pm and 03:00 pm. For away games, the assessment was completed before travel. Injured players did not take part in the assessment. The assessment times were determined in cooperation with the club and coaches. We used the German version of the RESTQ-Sport with 52 items. For four foreign players, the RESTQ-Sport was translated and was given in their own language using professional translators and back translation. The RESTQ-Sport 52 consists of seven general stress scales with two items per scale (General Stress, Emotional Stress, Social Stress, Conflicts/Pressure, Fatigue, Lack of Energy, Physical Complaints), five general recovery scales with two items per scale (Success, Social Recovery, Physical Recovery, General Well-Being, Sleep Quality), three sport-specific stress scales with four items per scale (Disturbed Breaks, Emotional Exhaustion, Injury) and four sport-specific recovery scales also with four items per scale (Being in Shape, Personal Accomplishment, Self-Efficacy, Self-Regulation) (Kellmann & Kallus, 2000, 2001). The questionnaire starts with a warm-up question and assesses recovery- and stress-related events and their subjective consequences. The general stress scale Social Stress asks about being annoyed by others or being angry with someone. The general stress scale Fatigue refers to being tired from work or feeling overtired. The general recovery scale Success asks if important decisions were made or if one was successful. The general recovery scale Sleep Quality asks about how satisfying the person's sleep was. The sport-specific stress scale Disturbed Breaks includes items such as a feeling of having too few breaks and not being able to obtain rest during the breaks. Another sport-specific stress scale is Injury, which includes items that refer to the feeling that the muscles are stiff or tense during performance and feeling vulnerable to injuries. The sport-specific recovery scale Self-Regulation asks about preparing oneself mentally for performance or setting definite goals for oneself during performance. Self-Efficacy is another sport-specific recovery scale. This scale asks about being convinced that one trained and performed well. Detailed descriptions of all scales are provided in Kellmann and Kallus (2000, 2001). The items are rated on a Likert-type scale ranging from 0 = never to 6 = always based on how often a specific event mentioned in the item occurred in the last three days/nights. High scores on the stress scales indicate a high level of stressful activities, whereas high scores on the recovery scales indicate a high level of activation that enhances the regaining of resources and recovery from stress. The scales have good internal consistency (0.67–0.89) and high test–retest reliability (>0.79) (Kellmann, 2010; Kellmann & Kallus, 2000, 2001).

Statistical analysis

We used the generalised linear model (GLM). The hypotheses relating stress and recovery to injuries were tested with the generalised estimating equations (GEE) method (Hanley, Negassa, Edwardes, & Forrester, 2003) employing an α value of 0.05. The RESTQ-Sport 52 scales that were completed every 4 weeks served as independent variables. Injury risk was the dependent variable. The stress and recovery

variables were always assessed before the onset of the injury and then used as predictors. From January 2010 until April 2011, a total of 222 measures of stress and recovery data were thus included in the analysis. Of these 222 RESTQ-Sport 52 assessments, 187 (84.2%) were not followed by an injury event, whereas 35 RESTQ-Sport 52 assessments (15.8%) were followed by one or more injury events. We collected a mean of 10.1 RESTQ-Sport 52 assessments per player (standard deviation 3.2). Since a player could suffer several injuries in the observation time period, these observations were treated as repeated measures that could vary between players. Because there was only a small number of injuries, traumatic and overuse injuries were collapsed into a general injury category. We used the Genmod procedure of the SAS 9.3. analysis system (SAS Institute, Cary, NC). Genmod permits the use of repeated measures using the GEE method. *Z*-tests served as test statistic (Proc Genmod). In addition, we computed odds ratios and the respective confidence intervals as a measure of the association between the stress and recovery variables and injury risk.

We used a predictive GLM where the dependent variable was injury risk. The odds ratios do not refer to cross-sectional data but in fact indicate the increase in injury risk per increase in the independent variables that were collected prior to the injury.

Results

Injuries and illnesses

During the study period, 34 traumatic injuries, 10 overuse injuries and 10 illnesses occurred. Because of the small total number of injuries (44) and illnesses (10), we did not differentiate between traumatic and overuse injuries and excluded illnesses in the statistical analysis. Most of the injuries were located in the lower limb (79.5%) (Figure 1). Figure 2 shows the number and severity of traumatic

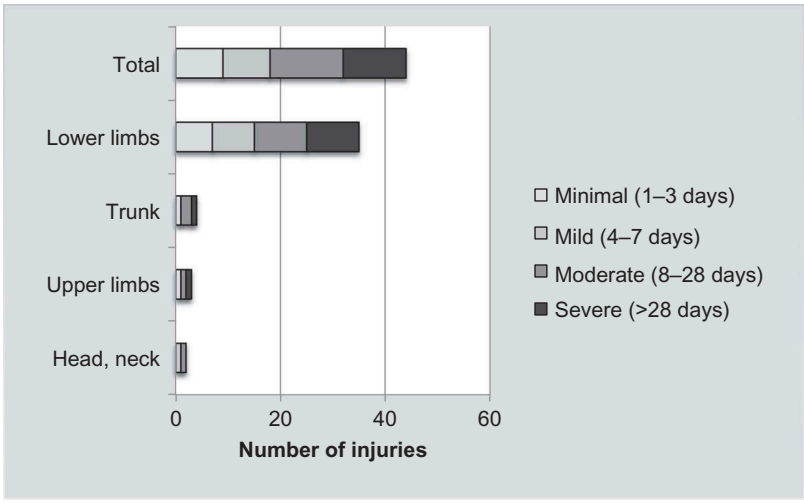

Figure 1. Injury location and severity of the injury in professional football players.

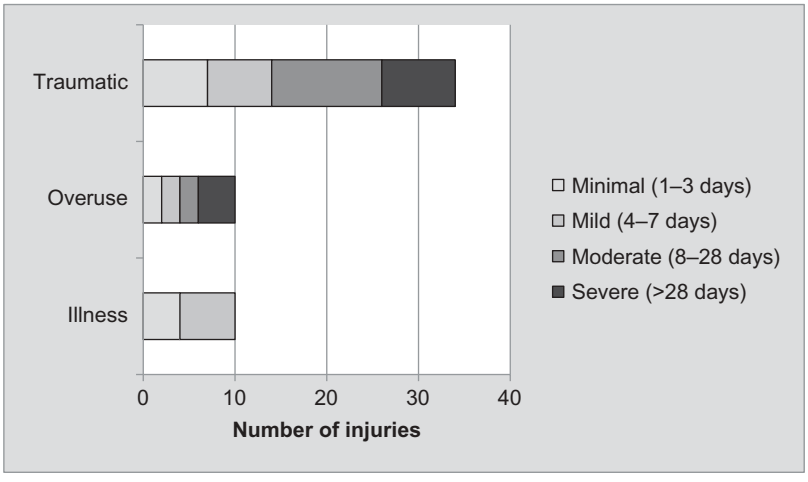

Figure 2. Injury mechanisms and severity in professional football players.

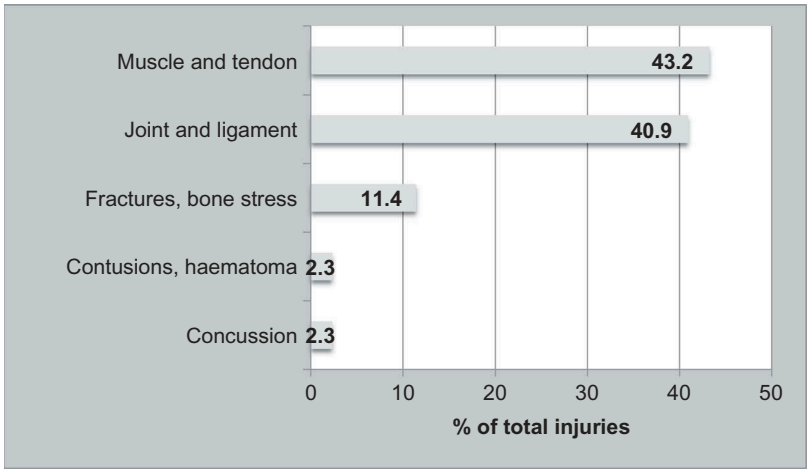

Figure 3. Injury types in professional football players.

and overuse injuries as well as illnesses. Muscle and tendon injuries (43.2%) were the most frequently occurring injury type (Figure 3). For the GLM, we only used the traumatic and overuse injuries.

Relation between recovery and stress, traumatic and overuse injuries

The general stress scale Fatigue (OR 1.70, CI 1.15–2.51, $P = 0.007$) and the sport-specific stress scales Disturbed Breaks (OR 1.84, CI 1.01–3.39, $P = 0.047$) and Injury (OR 1.77, CI 1.31–2.36, $P < 0.001$) were significantly positively related to injury risk (see Table I). The influence of the general recovery scale Sleep Quality (OR 0.53, CI 0.33–0.86, $P = 0.010$) on the variable injury was also significant, suggesting that low values on the scale Sleep Quality were associated with a higher subsequent risk of an injury. Figure 4 illustrates these data by showing pre-injury scores of a player 2 days before he became injured in comparison to the arithmetic mean of the other players. He had higher values on the general stress scale Fatigue (2.5) and the sport-specific stress scales Disturbed Breaks (1.8) and Injury (3.0). On the general recovery scale Sleep Quality (2.0), he showed lower values in comparison to the mean scores of the other players.

Table I. RESTQ-Sport scales as predictors for the risk of an injury.

Scales	*B*	*z*	*P*	OR	95% CI
General Stress	0.13	0.73	0.466	1.14	[0.80, 1.63]
Emotional Stress	0.04	0.31	0.760	1.04	[0.79, 1.39]
Social Stress	−0.09	−0.64	0.524	0.91	[0.70, 1.20]
Conflicts/Pressure	0.06	0.33	0.741	1.06	[0.74, 1.52]
Fatigue	**0.53**	**2.68**	**0.007****	**1.70**	**[1.15, 2.51]****
Lack of Energy	0.25	1.08	0.282	1.28	[0.81, 2.03]
Physical Complaints	0.05	0.22	0.825	1.05	[0.68, 1.62]
Success	0.01	0.06	0.953	1.01	[0.79, 1.27]
Social Recovery	−0.20	−1.04	0.300	0.82	[0.56, 1.20]
Physical Recovery	−0.19	−1.46	0.144	0.83	[0.64, 1.06]
General Well-Being	−0.00	−0.00	0.997	1.00	[0.77, 1.30]
Sleep Quality	**−0.63**	**−2.58**	**0.010***	**0.53**	**[0.33, 0.86]***
Disturbed Breaks	**0.61**	**1.98**	**0.047***	**1.84**	**[1.01, 3.39]***
Emotional Exhaustion	−0.34	−0.82	0.412	0.71	[0.31, 1.60]
Injury	**0.57**	**3.77**	**< 0.001****	**1.77**	**[1.31, 2.36]****
Being in Shape	−0.20	−1.36	0.174	0.82	[0.62, 1.09]
Personal Accomplishment	0.15	1.24	0.215	1.16	[0.91, 1.46]
Self-Efficacy	0.04	0.24	0.811	1.04	[0.77, 1.41]
Self-Regulation	−0.07	−0.48	0.631	0.93	[0.70, 1.26]

Notes: Results are shown as regression coefficients (*B*), z scores (*z*), significance levels (*P*), odds ratios (OR) and confidence intervals (CI). **P* < 0.05; ***P* < 0.01. Bold marks the scales that were significant predictors of injury risk in the entire sample.

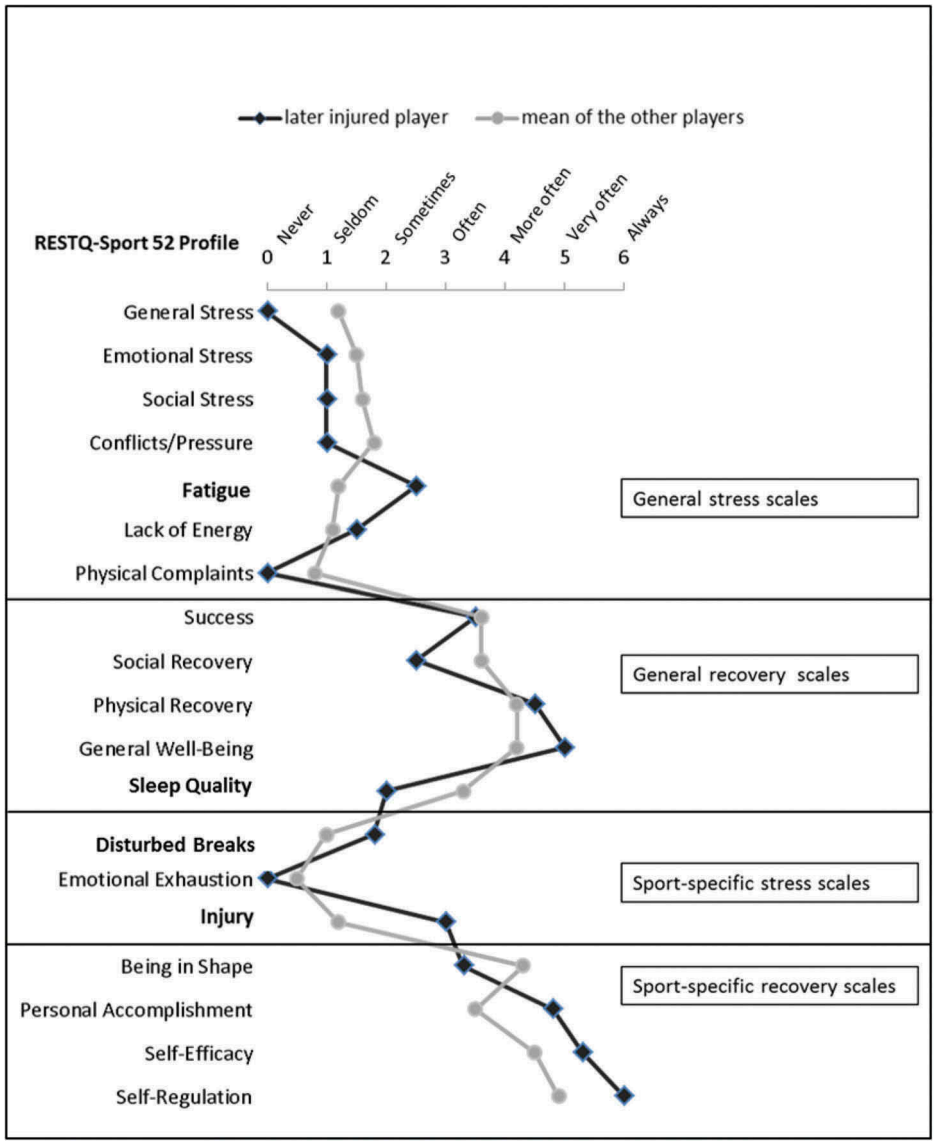

Figure 4. Recovery-Stress Questionnaire for Athletes profile for a male professional football player 2 days before injury in comparison to the arithmetic mean of the other players. Bold marks the scales that were significant predictors of injury risk in the entire sample.

Discussion

The aim of this study was to investigate the relation of the recovery–stress variables as assessed with the RESTQ-Sport and the injury risk of professional football players. The main result was a significant association of the general stress scale Fatigue, the sport-specific stress scales Disturbed Breaks and Injury and the general recovery scale Sleep Quality and the increasing risk of an injury.

These results are in accordance with the stress and injury model as proposed by Williams and Andersen (1998, 2007), although only a subset of the relevant variables were collected in this study. We did not specifically assess personality variables, stressor history or the history of previous injuries. However, the RESTQ-Sport assesses stressful situations that can be viewed as part of the stressor history as well as the ability of the player to recover from the stressors, which can be viewed as a measure of coping. We found that both acute stress and coping ability, as predicted by the model, contributed to injury risk. The general stress scale Fatigue measures excessive demands in the job and overfatigue without a possibility of recovery and this was also positively associated with injury risk. A very interesting association also occurred for the feeling of the muscles being stiff and the feeling to be prone to an injury. These factors also fit the assumption of the stress and injury model, which proposes generalised muscle tension and fear of injury to be important mediating factors between stress and injury. These perceptions may be important signs on the part of the players that rest periods should be made. In addition, the

recovery-related scale Sleep Quality was a significant predictor implying that a lack of sleep or non-refreshing sleep also increases injury risk. We did not assess a number of other potentially important recovery-related predictors of injury risk such as social support or stress management skills or medication (see Williams & Andersen, 1998, 2007). Brink et al. (2010) also reported a positive relationship between the RESTQ-Sport scale Injury and the occurrence of injury in their sample of elite youth football players. They found even more associations between illnesses and the general and sport-specific scales of the RESTQ-Sport. Because of the low number of illnesses, we could not investigate these relations in our study. Our results also complement the findings of Bengtsson et al. (2013) and Dupont et al. (2010) that short recovery periods increase significantly the number of injuries compared to longer recovery periods, although our data relied on subjective perceptions of stress and recovery. Further research needs to determine how objective and subjective measures of recovery are related and how they predict injury. It is possible that the perceived recovery rather than the objective length is the crucial variable as suggested by the model of Williams and Andersen (e.g. 2007), who emphasise that the perception of a stressor rather than the physical aspects of the stressor may have more impact on the athlete.

The association of the scales Fatigue, Disturbed Breaks, Injury and Sleep Quality suggests that injury risk increases if sufficient rest periods are lacking and if the player feels exhausted and overexerted. These deficits could lead to problems related to concentration and perception as well as increased muscle tension as physiological mediators of enhanced injury risk (Andersen & Williams, 1999), all variables that should be assessed in further studies. Specifically professional football players at the top level are exposed to a high amount of travelling, unfamiliar sleeping surroundings, interruption of circadian rhythm and a short recovery time (Dupont et al., 2010; Ekstrand et al., 2004; Meyer et al., 2013). The results of this study support the importance of good sleep quality and rest periods to prevent injuries in professional football.

These data also suggest that a monitoring of the recovery–stress balance of the players is important and useful to be able to intervene in time and to reduce the risk of an injury. The prospective nature of this study suggests that a lack of recovery and sleep and high stress as well as a feeling of muscle strain and impending injury precede the injury and predict its occurrence. Of course, injury can also be viewed as a stressor that can lead to less recovery as a consequence. Our results for injury type and location were comparable to the studies of Faude, Meyer, Federspiel, and Kindermann (2009), Noya Salces, Gómez-Carmona, Gracia-Marco, Moliner-Urdiales, and Sillero-Quintana (2014), Ekstrand (2013), and Ekstrand, Hägglund, and Waldén (2011) in professional and Brink et al. (2010) in elite youth football players. Our results are in accordance with these studies with most of the injuries in the lower limb (79.5%) and relating to muscles and tendons (43.2%). Traumatic injuries (77.3%) occurred more than overuse injuries (22.7%). Only the study of Noya Salces et al. (2014) reported more overuse (65.7%) than traumatic injuries (34.3%) in the first division Spanish football league.

This study has several advantages and several limitations. An advantage of our study is the longitudinal monitoring of the recovery and stress variables prior to the injury in real match and training situations in professional players of the highest league. The repeated-measures design improves the power of the study and permits clear predictive statements. The disadvantage of this non-experimental cohort design and all prospective cohort studies is that although prediction is possible, no causal relation between the results can be established. Factors like won or lost matches, away versus home matches, strength of the competitors or the teammates, tactical influence of the style of playing were not controlled and limit the generalisability of the study. Due to the fact that the study was performed in a professional football club who imposed a number of limitations on the study, we could only include 22 players. However, the multiple measurements over an extended period of time provided a total of 222 measurements that could be included in the prediction. Since the GLM we used does not provide data for the percentage of variance explained, effect sizes or power calculations, we estimated these parameters based on a logistic regression model. This yielded a generalised coefficient of determination of 3–5% for each variable that contributed significantly to the prediction of injury risk, effect sizes of 2.1–2.7 and power estimates ranging from 0.16 to 0.78, depending on the independent variable. Taken together, these data suggest that the RESTQ-Sport is a useful measure in the prediction of injury risk.

An additional limitation is that due to the small number of injuries we could not consider injury type as a variable. Further research in professional football must determine if similar predictors really hold for both injury types, i.e. traumatic and overuse injuries.

We only made assessments every 4 weeks from which we predicted injuries in the following 4 weeks. There were limitations that forced us to use a less frequent administration than might be desirable. We would have preferred more frequent assessments as they might yield better estimates of

the stress and injury relationship (cf. Timmons & Preacher, 2015) but this was not feasible in the participating club. The same circumstance applied for the length of the RESTQ-Sport. The club and the coaches supported only the use of the shortest official version of the RESTQ-Sport. Another limitation is that the official version of the RESTQ-Sport 52 only covers the last 3 days prior to the assessment rather than the entire month. Although it is possible that the 4 weeks prior to the assessment might have given more information, the players can give better information about the days just before testing and this may have assured less memory bias. More fine-grained analyses might yield even higher relationships between stress and recovery and injury and should be used in future studies. The coaches were informed about the results of the questionnaire and they might have responded differently to the players based on this information. However, training load was the same for all players and not individually adjusted based on this information. Another interesting variable to be considered in the prediction of injury is the change in stress or recovery measures. This can be tested by using latent growth curve models (cf. Ivarsson, Johnson, Lindwall, Gustafsson, & Altemyr, 2014). Our numbers were too small to do this. We only included stress and recovery variables in our analysis and omitted many other potentially predictive variables in this study. Nevertheless, one strength of this study is that the stress and recovery variables were always collected before the injury occurred and the odds ratios are thus not merely correlational but predictive, albeit limited to the variables we employed. Future studies also need to take into account other variables that may predict injury risk such as age, playing time or number of matches. Our data are thus clearly limited to the predictive role of perceived stress and recovery.

Finally, we used only questionnaire measures and no physiological variables, which could provide additional information on the psychophysical status free of any personal biases such as social desirability and false reporting (Meyer et al., 2013). However, studies like this one are important for building hypotheses, which can be examined in further investigations that include measures on several levels.

The prediction of injury risk from the recovery- and stress-related scales has important implications for the prevention of injuries. This information should be collected on a regular basis and be made available to the medical and psychological staff as well as to coaches and managers and the stakeholders of the clubs. Every injury of a player irrespective of its severity results in intensive treatment by the physiotherapists and medical staff, a higher rehabilitation workload for the fitness coaches, a missing player in the squad for the coaches and a financial loss for the club (Drawer & Fuller, 2002). The results of this study provide new insights to monitor and optimise the regeneration process in professional football.

These results support the importance of frequent monitoring of recovery and stress processes to further minimise the risk of injuries of professional football players. There is no single perfect method to analyse the recovery and stress processes of a player. With an interdisciplinary approach of physicians, physiotherapists, football coaches, fitness coaches, nutritionists and psychologists, it seems possible to develop a battery of different objective, reliable and valid tests to monitor the recovery–stress parameter of a player in the future (Meyer et al., 2013). One part of this test battery could be the RESTQ-Sport, which was used in this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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