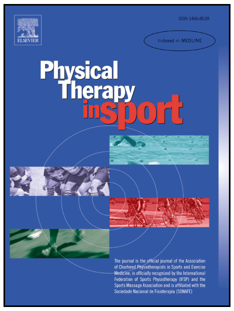
Accepted Manuscript



Parameters of low back pain chronicity among athletes: Associations with physical and mental stress

Jahan Heidari, Tobias Mierswa, Jens Kleinert, Ida Ott, Claudia Levenig, Monika Hasenbring, Michael Kellmann

PII: S1466-853X(16)00032-8

DOI: 10.1016/j.ptsp.2016.03.003

Reference: YPTSP 713

To appear in: *Physical Therapy in Sport*

Received Date: 27 August 2015

Revised Date: 29 January 2016

Accepted Date: 3 March 2016

Please cite this article as: Heidari, J., Mierswa, T., Kleinert, J., Ott, I., Levenig, C., Hasenbring, M., Kellmann, M., Parameters of low back pain chronicity among athletes: Associations with physical and mental stress, *Physical Therapy in Sports* (2016), doi: 10.1016/j.ptsp.2016.03.003.

MANUSCRIPT DRAFT

Parameters of low back pain chronicity among athletes: Associations with physical and mental stress

Jahan Heidari[a], Tobias Mierswa[a], Jens Kleinert[b], Ida Ott[b], Claudia Levenig[c], Monika Hasenbring[c], Michael Kellmann[a, d]

[a] Unit of Sport Psychology, Faculty of Sport Science, Ruhr University Bochum, Germany

Postal address: Gesundheitscampus Nord Nr. 10, 44801 Bochum, Germany

[b] Section Health & Social Psychology, Institute of Psychology, German Sport University Cologne, Germany

Postal address: Am Sportpark Muengersdorf 6, 50933 Cologne, Germany

[c] Department of Medical Psychology and Medical Sociology, Ruhr University Bochum, Germany

Postal address: Universitaetsstrasse 150, 44780 Bochum, Germany

[d] Schools of Human Movement Studies and Psychology, The University of Queensland, Australia

Postal address: Blair Drive, St Lucia QLD 4072, Australia

Email addresses (in order of authors):

jahan.heidari@rub.de, tobias.mierswa@rub.de, kleinert@dshs-koeln.de, i.ott@dshs-koeln.de, Levenig@medpsych.ruhr-uni-bochum.de, Hasenbring@medpsych.ruhr-uni-bochum.de, Michael.Kellmann@rub.de;

Corresponding author:

Jahan Heidari

Unit of Sport Psychology, Faculty of Sport Science, Ruhr University Bochum

Gesundheitscampus Nord Nr. 10, 44801 Bochum, Germany

Email address: jahan.heidari@rub.de

REVISED MANUSCRIPT DRAFT

Parameters of low back pain chronicity among athletes: Associations with physical and mental stress

Abstract

Objective: In the general population, physical and mental stress factors are linked to chronic low back pain (LBP). The aim of the present study was to examine this association among athletes.

Design: Longitudinal study with a six-month interval between measurements.

Setting: Questionnaires were filled out at home, either in paper-pencil version or online.

Participants: Eighty-two male and 57 female athletes (N = 139, $M_{Age\ =}$ 32.24) who exercise on a competitive (n = 102) or recreational level (n = 37), with a weekly training volume of at least three hours.

Main Outcome Measures: At T_0, stress parameters were assessed via the Recovery-Stress Questionnaire (RESTQ-Basic-48) and the Screening Scale of the Trier Inventory for the Assessment of Chronic Stress (TICS-SSCS). At T_0 and T_1, different chronification indicators were measured. Based on these assessments, the sample was split into a chronification and no-chronification group.

Results: ANCOVAs were used to conduct group comparisons with regard to stress levels. The chronification groups showed higher stress values for all chronification indicators. For the variables *Physical Complaints* and *Overall Stress-TICS*, the group differences became significant ($p < .05$).

Conclusion: A relationship between stress parameters and LBP chronification was demonstrated among athletes for the first time.

Keywords: psychological stress; low back pain; chronification; athletes

INTRODUCTION

Low back pain in athletes

Athletes are frequently confronted with physically challenging tasks. The performance of uncontrollable and demanding movements (e.g., body checking in ice hockey) is part of the training and competition routine in both contact and noncontact sports. As a result, athletes repeatedly suffer from persistent strains, especially in the lower back (Foss, Holme, & Bahr, 2012).

Trainor and Trainor (2004) summarized etiologic data from different studies comparing athletes' low back pain (LBP) prevalence rates. Several factors (e.g., age, type of sport) seem to affect the development of LBP. Bahr et al. (2004) demonstrated that endurance athletes in sports like rowing or cross-country skiing revealed a higher rate of LBP compared to nonathletic control groups. Their findings suggest that LBP appears to be a considerable burden across the abovementioned disciplines, with lifetime prevalence rates ranging between 51 % and 65 %. Specifically, a regular hyperextension of the back (e.g., figure skating, tennis) can cause injuries in the spine region and back-related problems (Bono, 2004; Hoskins, 2012; Schmidt et al., 2014).

Furthermore, a transition from acute LBP into a chronic condition may lead to several detrimental consequences. An ongoing chronification of LBP can result in diminished performance, injuries, and muscular deficits with regard to strength and flexibility (Ashmen & Swanik, 1996; de Jonge & Kramer, 2014; Nadler et al., 2002). Persistent LBP may even lead to a dropout of affected athletes and under elite conditions, to a loss of their main occupation (Hopkins & White, 1993; Maffulli, Longo, Gougoulias, Loppini, & Denaro, 2010). Approaches to cope with chronic LBP in athletes are primarily based on biomechanical and anatomical theories, as the development of chronic LBP in athletes is largely explained by these physiological approaches (Bahr et al., 2004; Daniels, Pontius, El-Amin, & Gabriel, 2011). Nevertheless, many athletes continue to suffer from pain and disability symptoms without underlying tissue pathology (Iwamoto, Takeda, & Wakano, 2004). For athletes, Puentedura and Louw (2012) recommend a biopsychosocial approach of LBP examination with a special focus on psychosocial factors. Hoskins (2012) and Wiech, Ploner, and Tracey (2008) state that psychological and stress-related factors can potentially be associated with a chronification of LBP among athletes.

Stress in the world of sport

Stress is a multifaceted and omnipresent phenomenon for athletes. External factors influence an athlete's experience of stress, for example extensive travel times or a high training volume. Several influences interact and require the athlete's physiological and psychological resources (e.g., stamina, concentration) (Hanton, Fletcher, & Coughlan, 2005; Mellalieu, Neil, Hanton, & Fletcher, 2009). A subsequent stress response can manifest on a physiological, emotional, social, or cognitive level (Buckworth, Dishman, O'Connor, & Tomporowski, 2013). In case sufficient recovery fails to appear, chronic stress can develop contributing to several detrimental outcomes (Kellmann, 2000, 2002). Dysfunctional stress patterns among athletes can generate health-related problems that could lead to severe diseases. For example, they may affect the immune system (Clow & Hucklebridge, 2001), the mental health (Hughes & Leavey, 2012), and the musculoskeletal system (Brenner, 2007; Galambos, Terry, Moyle, Locke, & Lane, 2005).

For LBP, there is a paucity of studies examining the association with stress in sport participants, although the relationship between acute and chronic LBP and different facets of stress has been comprehensively studied in the general population (Linton, 2000; Pincus, Burton, Vogel, & Field, 2002). Identically, the role of stress has been considered in thematically-related fields, such as injuries among athletes (Andersen & Williams, 1999; Galambos et al., 2005; Laux, Krumm, Diers, & Flor, 2015; Williams & Andersen, 2007). Only Galambos et al. (2005) emphasize the impact of mood and stress factors for the prediction of back pain. The findings are in line with the assumptions from other research in this field (Hoskins, 2012; Puentedura & Louw, 2012; Standaert, Herring, & Pratt, 2004) and underline a potential association between stress and LBP in sport samples.

For this reason, the purpose of the present study was to examine the role of stress in the context of LBP chronification among athletes. Specifically, we investigated the prediction of different facets of stress with regard to pain and disability indicators of LBP chronification. It was hypothesized that athletes with higher physical and psychological stress loads tend to show LBP chronification over time. To the best of our knowledge, neither for the onset of LBP, nor for the chronification of LBP, stress-related factors among athletes have been examined.

METHOD

Participants

The a priori sample size calculation was carried out with the program G*Power 3.0 (Faul, Erdfelder, Lang, & Buchner, 2007). We used a conventional alpha of .05 and a power of .80 with an allocation ratio of 1 regarding the groups. The smallest effect of interest was fixed at a medium to high level of d = 0.6 (Cohen, 1992). We followed the guidelines suggested by Noordzij et al. (2010) to specify the parameters of the sample size calculation. Finally, a total minimum sample size of 90 participants was required to ensure the determined effect size.

The sample consisted of 139 athletes (M_{Age} = 32.24, SD_{Age} = 11.32). The distribution of gender was relatively balanced, with 57 women in the athletic group. To note, the athletic sample formed a subsample of a study of the **X** project in the context of **X**. Basic inclusion criteria to be eligible for participation were: (a) at least 18 years old; (b) the presence of nonspecific LBP, based on the self-assessment of the athletes; and (c) the participation in some form of prescribed active exercise therapy (e.g., physiotherapy) with a health care professional. Participants were excluded based on the following conditions: (a) rheumatic diseases; (b) acute fractures; (c) infections; (d) tumors; (e) diagnosed herniated disks with paresis; (f) pregnancy. The overall sample at the first measurement point (T_0) included 267 participants with both an athletic and nonathletic background, as a comparison between those two groups was anticipated in the first place. At the six-month follow-up (T_1), the sample consisted of 172 participants (athletes and nonathletes), with 139 individuals being categorized as athletes. For the classification as an athlete, individuals had to fulfill two minimum criteria: (a) a certain competition level (at least recreational level); (b) weekly training volume (at least three hours). If either the competition level or the training volume did not meet the required benchmarks, the participant was not classified as an athlete in this study. Based on these standards, participants were labeled as either competitive (*n* = 102) or recreational (*n* = 37) athletes. Athletes assigned to the competitive group engaging in competitions on a national or even international level with a weekly training volume of at least five hours. In contrast, athletes in the recreational group (*n* = 37) participated in regional competitions and had to train at least three hours a week. The allocation criteria for the athletic assignment were derived from basic definitions of an athlete and physical activity (Haskell et al., 2007; Weineck, 2009).

<u>Materials</u>

Chronification variables

Two pain characteristics and one comprehensive disability indicator targeting the LBP region were measured with the scales *Characteristic Back Pain in the Last Three Months, Average Back Pain in the Last Three Months,* and *Disability Score in the Last Three Months.* The scales were gathered from the validated German version of the Chronic Pain Grade (Klasen, Hallner, Schaub, Willburger, & Hasenbring, 2004) which was originally developed by Von Korff, Ormel, Keefe, and Dworkin (1992). We used the validated translation of the scales to guarantee for the generalizability of the results. For both pain and disability, a composite score can be created. The calculation procedures are based on the German version of the Chronic Pain Grade (Klasen et al., 2004). This instrument entails the two factors *Characteristic Back Pain Intensity* and *Disability Score in the Last Three Months*. Three different dimensions form the *Characteristic Back Pain Intensity* factor, namely *Average Back Pain Intensity in the Last Three Months, Intensity of Back Pain in the Last Three Months*, and *Intensity of Back Pain at the Moment.* All pain items range from 0 (*no pain*) to 10 (*pain as bad* *could be*). The reliability analysis yielded a good internal consistency score of α = .83 at T_0. Identically, the *Disability Score in the Last Three Months* can be formed. The disability parameter is operationalized via three different statements, which refer to the previous three months: (a) the number of days with disability; (b) disability-related interference with daily activities; (c) changes within the work, social and leisure time setting due to a perceived disability. Again, the scales range from 0 (*no interference*) to 10 (*unable to carry on any activities*). Based on the disability points obtained from these data, an overall *Disability Score in the Last Three Months* can be calculated. A Cronbach's alpha of α = .87 described the internal consistency of the disability scale. Validity analyses by Klasen et al. (2004) produced moderate statistical associations between the pain and disability scales and other clinical variables and measures.

Stress variables

For this study, the *Overall Stress* dimension of the German version of the Recovery-Stress Questionnaire Basic with 48 items was utilized (RESTQ-Basic-48; Kallus, 2016). An *Overall Recovery* factor also exists. In the context of this study, only the *Overall Stress* scales have been considered, as the current research mainly focused on stress-related parameters.

The *Overall Stress* dimension entails seven scales, with each scale consisting of four items. These scales are *General Stress*, *Emotional Stress*, *Social Stress*, *Conflicts/Pressure*, *Fatigue*, *Lack of Energy*, and *Physical Complaints*. Participants have to specify the frequency of certain events within the time frame of three days on a Likert-type scale with values ranging from 0 (*never*) to 6 (*always*). For each scale, an average value is calculated. For this sample, all scales at least show acceptable internal consistencies, ranging from α = .67 to α = .90. Moreover, the RESTQ-Basic has demonstrated its discriminant and convergent validity with several psychological and physiological instruments within multiple populations (Kallus, 2016).

As a second measure of stress, the participants had to fill out the Screening Scale of the Trier Inventory for the Assessment of Chronic Stress (TICS-SSCS; Schulz, Schlotz, & Becker, 2004). The TICS-SSCS consists of 12 items, which include the stress domains of *Chronic Worrying*, *Work-Related Overload*, *Social Overload*, *Excessive Demands*, and *Lack of Social Recognition.* This screening instrument assesses the frequency of self-perceived overall stress in the last three months. For clarification, the overall stress measured with the TICS-SSCS is labeled as *Overall Stress-TICS*. The scales range from 0 (*never*) to 4 (*very often*) and in the end, an average score can be calculated. The internal consistency for the TICS-SSCS was $\alpha = .91$ for this sample. Validity examinations of the questionnaire were performed under discriminant and convergent aspects. Data were assessed with different samples and thematically related instruments regarding acute stress, chronic stress, and psychological constructs (Schulz et al., 2004).

Procedure

The participants were asked to complete a questionnaire package comprising sections for the social, pain, activity, and stress anamnesis. Data were assessed via a longitudinal approach at two time points, with a six-month interval between the measurements (T_0; $T_{1)}$. Participants for the study were recruited in two different ways. First, physiotherapists, sport therapists, and chiropractors from **X** were contacted. They informed clients with LBP about the study. Interested individuals participated in a telephone survey and were screened for the abovementioned inclusion and exclusion criteria. All participants gave their written consent before they took part in the survey. After that, the suitable participants received the entire questionnaire package in paper-pencil form. The second approach was via an online delivery of the questionnaire package using the software EFS Survey by *Questback GmbH*. A link to this online version was launched on different websites of German sport federations (e.g., regional and national base camps) together with basic information about the study. A great variety of federations was originally contacted to allow for a diverse sample of athletes gathered from disciplines like archery, volleyball, hockey, or soccer (see Table 1). Inclusion and exclusion criteria were checked at the beginning of the online questionnaire. For their informed consent, participants had to click on a button on the first page of the online version. At the end of the study, the participants were compensated with a 10 Euro voucher and received feedback about general outcomes of the study. The study was approved by the Medical Ethic Committee of the **X.**

Data analysis

A response pattern check of the answers was performed with the entire dataset. Several researchers scanned the dataset and looked for irregularities in the data input. This process was conducted with regard to the range of the items and with regard to logical errors in combined items. Three invalid cases were identified and subsequently excluded. As a next step of the data preparation, an outlier analysis was performed based on the guidelines summarized by Iglewicz and Banerjee (2001). Next, chronification indices for relevant variables were determined by calculating the differences between the chronification values of the two measurements (T_1 - T_0). Subsequently, two dichotomous groups were formed (chronification/no-chronification). The athletes with a positive or zero value were assigned to the chronification group, as these values were equivalent to an increase of chronification or a steady chronic level of LBP. Athletes with negative values were allocated to the no-chronification group, as negative values reflected a reduction of the chronification. This procedure was performed for the variables *Characteristic Back Pain in the Last Three Months*, *Average Back Pain in the Last Three Months* and *Disability Score in the Last Three Months* in an identical manner.

Statistically, eight one-way ANCOVAs were conducted for each of the three chronification indices. The two groups of each chronification variable were separately examined for differences in the stress parameters. To control for potential biasing differences at T_0, the respective chronification value of each chronification group at T_0 was included as a covariate (e.g., *Characteristic Back Pain in the Last Three Months* at T_0). Due to the high number of group comparisons via ANCOVAS, adjustments for multiple testing via the Bonferroni method are frequently recommended. Nevertheless, we refrained from applying this procedure as it would have led to a considerable increase of type II errors (i.e., the probability of accepting the null hypothesis when the alternative is correct). Another pitfall of the Bonferroni adjustment refers to the interpretation of the findings. According to Perneger (1998), the outcomes highly depend on the number of other tests performed. In this study, we approach a rather new field of research and therefore conduct plenty of group comparisons in an explorative way.

Finally, all assumptions for applying ANCOVAs as statistical procedure were checked with a preliminary analysis. The main prerequisites regarding sample size, measurement level, normality, homogeneity of regression slopes, and homogeneity of variances were satisfactorily met. All analyses were conducted using SPSS Version 22.0 (SPSS, Inc., Chicago, IL).

RESULTS

One hundred and thirty-nine individuals have been classified as athletes based on the inclusion criteria, but the group sizes in the analyses varied due to missing data regarding some parts of the questionnaire battery. Presumably, this occurred because some participants did not fill in the questionnaires with sufficient thoroughness. Central characteristics of the investigated sample are portrayed descriptively in Table 1.

Table 1

Selected Characteristics of the athletic sample

Variable of Interest	Mean ± SD/Number of responses		
LBP Duration	914.4 ± 1505.4 days		
Type of Sport	Archery (*n* = 13)	Hockey (*n* = 10)	Volleyball (*n* = 10)
Sport as Profession	Yes (*n* = 14)	No (*n* = 125)	

Note. Only the three most frequent types of sports are listed.

The subsequent group comparisons are organized with respect to the chronifcation categories of pain and disability. *Characteristic Back Pain in the Last Three Months* and *Average Back Pain in the Last Three Months* represent the pain scales, whereas *Disability Score in the Last Three Months* described disability.

The ANCOVA for the *Characteristic Back Pain in the Last Three Months* variable yielded significant results for two dependent variables. As a covariate, the *Characteristic Back Pain in the Last Three Months* levels at T_0 were included. *Physical Complaints* significantly differed between the groups, $F(1,134) = 6.03$, $p = .015$, $\eta_p^2 = .04$, with the covariate also showing a significant influence, $F(1,134) = 44.37$, $p < .001$, $\eta_p^2 = .25$. Furthermore, the athletes differed in their *Overall Stress-TICS* levels, $F(1,125) = 5.40$, $p = .022$, $\eta_p^2 = .04$. Again, the covariate also became significant, $F(1,125) = 10.25$, $p = .002$, $\eta_p^2 = .08$. The remaining dependent variables did not reveal any significant group differences for chronification (Table 2).

The ANCOVAs for chronification vs. no-chronification regarding *Average Back Pain in the Last Three Months* included the covariate *Average Back Pain in the Last Three Months* at T_0. A statistically significant group difference was found for *Physical Complaints*, $F(1,134) = 3.99$, $p = .048$, $\eta_p^2 = .03$. In this ANCOVA, the covariate also showed a significant impact, $F(1,134) = 35$, $p < .001$, $\eta_p^2 = .21$. For *Overall Stress-TICS*, the groups also differed, $F(1,125) = 8.07$, $p = .005$, $\eta_p^2 = .06$. A comparable result was identified for the covariate, $F(1,125) = 16.33$, $p < .001$, $\eta_p^2 = .12$. The descriptive values are listed in Table 2.

Table 2

Descriptive Group Comparisons for Characteristic Back Pain and Average Back Pain in the Last Three Months

		Chronification group		No-chronification group	
Dependent Variables	Cronbach's α	Characteristic Back Pain (n = 44/40)[a]	Average Back Pain (n = 60/57)[a]	Characteristic Back Pain (n = 93/88)[a]	Average Back Pain (n = 77/71)[a]
General Stress	α = .88	1.62 (1.18)	1.54 (1.10)	1.31 (1.12)	1.30 (1.18)
Emotional Stress	α = .75	1.70 (0.78)	1.63 (0.81)	1.54 (0.91)	1.57 (0.92)
Social Stress	α = .90	1.85 (1.15)	1.77 (1.13)	1.74 (1.12)	1.78 (1.14)
Conflicts/ Pressure	α = .67	2.20 (0.95)	2.20 (1.01)	1.99 (1.01)	1.95 (0.97)
Fatigue	α = .79	2.19 (1.12)	2.13 (1.14)	2.06 (1.09)	2.08 (1.10)
Lack of Energy	α =.68	1.87 (1.14)	1.80 (1.01)	1.84 (0.91)	1.89 (0.96)
Physical Complaints	α = .73	2.34 (1.17)*	2.20 (1.12)*	2.00 (1.01)	2.03 (1.03)
Overall Stress-TICS	α = .91	1.78 (0.84)*	1.73 (0.76)**	1.53 (0.66)	1.51 (0.69)

Note. The values in the columns show the mean and standard deviation of each stress parameter in the respective group.
[a]The second n-value in the brackets refers to the distribution of the *Overall Stress-TICS*.
*p < .05. **p < .01.

No statistically significant result was obtained for the disability measure *Disability Score in the Last Three Months.*

DISCUSSION

The aim of the present study was to examine stress parameters in athletes with regard to different indicators of LBP chronification. It was hypothesized that the individuals with an increase or steady level of chronification between T_0 and T_1 should show higher stress levels at T_0, compared to the athletes with a decline of chronification.

To a certain extent, the outcomes support the initial hypothesis that higher stress levels are associated with a chronification of LBP. Group differences occurred for two stress variables (*Overall Stress-TICS*, *Physical Complaints*) with regard to the pain chronification indicators (*Characteristic Back Pain in the Last Three Months, Average Back Pain in the Last Three Months*).

No statistically significant relationships between stress parameters and the disability measure were yielded. Notably, all mean values of the reported stress variables were higher in the chronification group compared to the no-chronification group across all chronifcation indicators.

Interpretation of the outcomes

The findings of the *Overall-Stress-TICS* scale suggest that individuals with a higher stress level within the previous three months of T_0 reported an increase of LBP between the measurements. Pain which is related to chronification was therefore predicted by elevated chronic stress stemming from different factors (e.g., work, leisure time). A constant stress burden may have led to changes in the pain perception and the awareness of pain in the lower back area in athletes. Research shows that stress-induced chronic pain can stimulate alterations in neuronal networks with attentional shifts towards pain (Simons, Elman, & Borsook, 2014; Standaert et al., 2004; Wiech et al., 2008). Neural and muscular structures in the lower back reveal a higher proneness to chronic pain

(Punnett et al., 2005; Wheeler, Schneck, Talavera, Halsey, & Berman, 2014). Over time, a vicious circle of pain-stress reactivity establishes, because ongoing pain fosters stressful experiences for the affected athletes (Gatchel, Peng, Peters, Fuchs, & Turk, 2007; Melzack, 2005). Although studies report a higher pain tolerance and more adaptive pain coping for athletes (Daniels et al., 2011), the current results indicate that heavy stress may generate an increase of LBP for athletes in this sample. Another interpretation of the findings suggests that the quality of pain leading to a chronifcation might have produced more stress for the affected athletes. Nevertheless, the significant differences for the *Physical Complaints* scale underline the role of stress, which is related to physical sensations. A higher overall stress burden may have manifested in physical stress and physical problems (e.g., other musculoskeletal disorders), which promote a chronification of LBP (Ramond-Roquin et al., 2015). Physical stress can be characterized as a predominantly sport-related phenomenon, presumably related to the anatomical region of the LBP (Apostolos, 2013; Trainor & Trainor, 2004). As athletes typically have to deal with exceptionally high physical demands and strains, higher somatic stress loads can result. Maladaptive mental and physiological processes might be stimulated that favor the development of LBP. Without sufficient recovery, these physical problems may lead to detrimental outcomes, such as overtraining (Angeli, Minetto, Dovio, & Paccotti, 2004; Hausswirth et al., 2014; Main, Dawson, Grove, Landers, & Goodman, 2009), injuries (Ivarsson, Johnson, Lindwall, Gustafsson, & Altemyr, 2014; Laux et al., 2015; Storheim & Zwart, 2014), or a persistent pain-related LBP burden in the current sample.

Notably, significant associations between stress parameters and a LBP chronification were only found for pain-related chronification indicators, but not for the disability measure. A possible reason for this outcome might be that athletes are unaware of their stress levels, which may play an indirect role by initiating physiological processes that increase pain. Stress therefore modifies the development of pain. With disability, the athletes in the chronification group did not show a higher stress level than those in the no-chronification group. Possibly, stress did not have an impact on the perceived disability, because athletes are constantly confronted with challenging situations. They are used to deal with external and internal stressors without feeling limited by them. Another explanation targets the role of pain and disability with regard to back pain. The review of Wiech et al. (2008) states that the relationship of pain and disability is mediated by several factors. For example, psychological stress mediates the effect of pain on disability. The direction of this mediation could have been different in this sample of athletes, with pain mediating the effect between stress and disability associated with LBP.

In the context of this study, athletes displayed pain chronification together with higher stress levels at T_0, both for the overall stress and the physical component.

Within the general population, several studies have identified a considerable association between psychological stress and chronic LBP (Linton & Shaw, 2011; Scholich, Hallner, Wittenberg, Hasenbring, & Rusu, 2012). Nevertheless, a relationship between a chronification of LBP and increased stress levels has not been precisely studied among athletes up to the present moment.

Limitations and future directions

The chronification measurements were conducted at two time points, whereas the stress parameters were exclusively assessed at T_0. This procedure was in line with other studies in the context of LBP chronification (Hampel & Moergel, 2009; Mehling et al., 2011; Waddell, 2006). Nevertheless, the findings from the measurement design of this study only provide partial support for chronification over time. With the included measures, the picture of the last three months with regard to LBP pain and disability was considered. Referring to this data, it cannot be stated how the individual level of LBP chronification was between the time points. Variations might have occurred with regard to the stress levels, which were solely assessed at T_0.

Moreover, a random group allocation of the participants or an experimental examination of the influence of stress did not occur. Future designs should include baseline measurements and interventions for the assessment of causal relationships (e.g., a comparison between athletes and nonathletes via a stress reduction program). This approach is suggested by Bongers, Ijmker, van den Heuvel, and Blatter (2006) as well as Reese and Mittag (2013).

Finally, due to the study design and heterogeneous sample of athletes, the results and conclusions of this study cannot be generalized. Hence, the association of the group comparisons is relatively weak considering the respective effect sizes, which ranged between η_p^2 = .03 - .06. In line with the literature, these effect sizes can be characterized as small with respect to the practical interpretability (Ferguson, 2009; Vacha-Haase & Thompson, 2004).

In future studies, it is necessary to investigate the relation between stress parameters, LBP chronification, and sport activity to challenge or affirm the findings of this study (Kovacs, Abraira, Zamora, & Fernández, 2005). The impact of stress should be studied among athletes whose chronification stage can be characterized as subacute, in order to observe the influence of stress patterns for a transition into a chronic state. Besides, potential differences between different sport types should be examined, as every sports discipline requires a specific profile with respect to the athletes' psychological and physiological capacities.

Conclusions

This study enhances the understanding of the genesis of chronic LBP among athletes, with a special focus on the stress concept. Somatic aspects of stress were more pronounced for athletes with an ongoing chronification process, compared to emotional or social facets of stress. The present results might serve as a starting point for further investigations with regard to the stress load of athletes and the development of injuries, chronic diseases, and LBP. Clinicians and coaches could equally benefit from the findings under a practical perspective. With the knowledge of psychological stress contributing to a detrimental LBP development, preventive steps could be pushed ahead via the diagnosis and monitoring of recovery and stress states of athletes.

Funding

The present study was initiated and funded by the German Federal Institute of Sport Science (IIA1–080102B/11–14). The research was realized within MiSpEx – The National Research Network for Medicine in Spine Exercise.

REFERENCES

Andersen, M. B., & Williams, J. M. (1999). Athletic injury, psychosocial factors and perceptual changes during stress. *Journal of Sports Sciences, 17*(9), 735-741. doi: 10.1080/026404199365597

Angeli, A., Minetto, M., Dovio, A., & Paccotti, P. (2004). The overtraining syndrome in athletes: a stress-related disorder. *Journal of Endocrinological Investigation, 27*(6), 603-612. doi: 10.1007/bf03347487

Apostolos, S. (2013). Why are elite athletes suffering from low back pain? *Biology of Exercise, 9*(2), 5-7.

Ashmen, K. J., & Swanik, C. B. (1996). Strength and flexibility characteristics of athletes with chronic low-back pain. *Journal of Sport Rehabilitation, 5*(4), 275-286.

Bahr, R., Andersen, S. O., Loken, S., Fossan, B., Hansen, T., & Holme, I. (2004). Low back pain among endurance athletes with and without specific back loading – a cross-sectional survey of cross-country skiers, rowers, orienteerers, and nonathletic controls. *Spine, 29*(4), 449-454.

Bongers, P. M., Ijmker, S., van den Heuvel, S., & Blatter, B. M. (2006). Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioural perspective (part II). *Journal of Occupational Rehabilitation, 16*(3), 279-302. doi: 10.1007/s10926-006-9044-1

Bono, C. M. (2004). Low-back pain in athletes. *The Journal of Bone and Joint Surgery, 86*(2), 382-396.

Brenner, J. S. (2007). Overuse injuries, overtraining, and burnout in child and adolescent athletes. *Pediatrics, 119*(6), 1242-1245. doi: 10.1542/peds.2007-0887

Buckworth, J., Dishman, R. K., O'Connor, P. J., & Tomporowski, P. (2013). *Exercise Psychology* (2nd ed.). Champaign, IL: Human Kinetics.

Clow, A., & Hucklebridge, F. (2001). The impact of psychological stress on immune function in the athletic population. *Exercise Immunology Review, 7*, 5-17.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155.

Daniels, J. M., Pontius, G., El-Amin, S., & Gabriel, K. (2011). Evaluation of low back pain in athletes. *Sports Health*, *3*(4), 336-345. doi: 10.1177/1941738111410861

de Jonge, M. C., & Kramer, J. (2014). Spine and sport. *Seminars in Musculoskeletal Radiology, 18*(3), 246-264. doi: 10.1055/s-0034-1375568

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Ferguson, C. J. (2009). An effect size primer: a guide for clinicians and researchers. *Professional Psychology: Research and Practice, 40*(5), 532.

Foss, I. S., Holme, I., & Bahr, R. (2012). The prevalence of low back pain among former elite cross-country skiers, rowers, orienteerers, and nonathletes: a 10-year cohort study. *American Journal of Sports Medicine, 40*(11), 2610-2616. doi: 10.1177/0363546512458413

Galambos, S. A., Terry, P. C., Moyle, G. M., Locke, S. A., & Lane, A. M. (2005). Psychological predictors of injury among elite athletes. *British Journal of Sports Medicine*, *39*(6), 351-354. doi: 10.1136/bjsm.2005.018440

Gatchel, R. J., Peng, Y. B., Peters, M. L., Fuchs, P. N., & Turk, D. C. (2007). The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychological Bulletin, 133*(4), 581-624. doi: 10.1037/0033-2909.133.4.581

Hampel, P., & Moergel, M. F. (2009). Schmerzchronifizierung bei Rückenschmerzpatienten in der stationären Rehabilitation: zur Validität des Mainzer Stadienmodells der Schmerzchronifizierung [Staging of pain in patients with chronic low back pain in inpatient rehabilitation: validity of the Mainz Pain Staging System of pain chronification]. *Schmerz*, *23*(2), 154-165. doi: 10.1007/s00482-008-0743-8

Hanton, S., Fletcher, D., & Coughlan, G. (2005). Stress in elite sport performers: a comparative study of competitive and organizational stressors. *Journal of Sports Sciences, 23*(10), 1129-1141. doi: 10.1080/02640410500131480

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise, 39*(8), 1423-1434. doi: 10.1249/mss.0b013e3180616b27

Hausswirth, C., Louis, J., Aubry, A., Bonnet, G., Duffield, R., & Le Meur, Y. (2014). Evidence of disturbed sleep and increased illness in overreached endurance athletes. *Medicine and Science in Sports and Exercise, 46*(5), 1036-1045. doi: 10.1249/mss.0000000000000177

Hopkins, T. J., & White, A. A. (1993). Rehabilitation of athletes following spine injury. *Clinics in Sports Medicine, 12*(3), 603-619.

Hoskins, W. (2012). Low back pain and injury in athletes. In Y. Sakai (Ed.), *Low back pain pathogenesis and treatment* (pp. 41-69). Rijeka: InTech.

Hughes, L., & Leavey, G. (2012). Setting the bar: athletes and vulnerability to mental illness. *The British Journal of Psychiatry, 200*(2), 95-96. doi: 10.1192/bjp.bp.111.095976

Iglewicz, B., & Banerjee, S. (2001). *A simple univariate outlier dentification procedure.* Paper presented at the proceedings of the annual meeting of the American Statistical Association, Atlanta, GA.

Ivarsson, A., Johnson, U., Lindwall, M., Gustafsson, H., & Altemyr, M. (2014). Psychosocial stress as a predictor of injury in elite junior soccer: a latent growth curve analysis. *Journal of Science & Medicine in Sport, 17*(4), 366-370. doi: 10.1016/j.jsams.2013.10.242

Iwamoto, J., Takeda, T., & Wakano, K. (2004). Returning athletes with severe low back pain and spondylolysis to original sporting activities with conservative treatment. *Scandinavian Journal of Medicine & Science in Sports, 14*(6), 346-351. doi: 10.1111/j.1600-0838.2004.00379.x

Kallus, K. W. (2016). Chapter 2: RESTQ-Basic: the general version of the RESTQ. In K. W. Kallus & M. Kellmann (Eds.), *The Recovery-Stress Questionnaires: User manual* (pp. 49-85). Frankfurt: Pearson.

Kellmann, M. (2000). Psychologische Methoden der Erholungs-Beanspruchungs-Diagnostik [Psychological methods for the assessment of recovery and stress]. *Deutsche Zeitschrift für Sportmedizin, 51*(7,8), 253-258.

Kellmann, M. (2002). Underrecovery and overtraining: different concepts – similar impact? In M. Kellmann (Ed.), *Enhancing recovery: Preventing underperformance in athletes* (pp. 3-24). Champaign, IL: Human Kinetics.

Klasen, B. W., Hallner, D., Schaub, C., Willburger, R., & Hasenbring, M. (2004). Validation and reliability of the German version of the Chronic Pain Grade questionnaire in primary care back pain patients. *GMS Psycho-Social-Medicine, 1*, 1-12.

Kovacs, F. M., Abraira, V., Zamora, J., & Fernández, C. (2005). The transition from acute to subacute and chronic low back pain: a study based on determinants of quality of life and prediction of chronic disability. *Spine, 30*(15), 1786-1792.

Laux, P., Krumm, B., Diers, M., & Flor, H. (2015). Recovery-stress balance and injury risk in professional football players: a prospective study. *Journal of Sports Sciences, 33*(20), 2140-2148. doi: 10.1080/02640414.2015.1064538

Linton, S. J. (2000). A review of psychological risk factors in back and neck pain. *Spine, 25*(9), 1148-1156.

Linton, S. J., & Shaw, W. S. (2011). Impact of psychological factors in the experience of pain. *Physical Therapy, 91*(5), 700-711. doi: 10.2522/ptj.20100330

Maffulli, N., Longo, U. G., Gougoulias, N., Loppini, M., & Denaro, V. (2010). Long-term health outcomes of youth sports injuries. *British Journal of Sports Medicine*, *44*(1), 21-25. doi: 10.1136/bjsm.2009.069526

Main, L. C., Dawson, B., Grove, J. R., Landers, G. J., & Goodman, C. (2009). Impact of training on changes in perceived stress and cytokine production. *Research in Sports Medicine*, *17*(2), 121-132. doi: 10.1080/15438620802689757

Mehling, W. E., Gopisetty, V., Acree, M., Pressman, A., Carey, T., Goldberg, H., . . . Avins, A. L. (2011). Acute low back pain and primary care: how to define recovery and chronification? *Spine, 36*(26), 2316-2323. doi: 10.1097/BRS.0b013e31820c01a6

Mellalieu, S. D., Neil, R., Hanton, S., & Fletcher, D. (2009). Competition stress in sport performers: stressors experienced in the competition environment. *Journal of Sports Sciences, 27*(7), 729-744. doi: 10.1080/02640410902889834

Melzack, R. (2005). Evolution of the neuromatrix theory of pain. The Prithvi Raj Lecture: presented at the third world congress of World Institute of Pain, Barcelona 2004. *Pain Practice, 5*(2), 85-94. doi: 10.1111/j.1533-2500.2005.05203.x

Nadler, S. F., Moley, P., Malanga, G. A., Rubbani, M., Prybicien, M., & Feinberg, J. H. (2002). Functional deficits in athletes with a history of low back pain: a pilot study. *Archives of Physical Medicine and Rehabilitation, 83*(12), 1753-1758. doi: 10.1053/apmr.2002.35659

Noordzij, M., Tripepi, G., Dekker, F. W., Zoccali, C., Tanck, M. W., & Jager, K. J. (2010). Sample size calculations: basic principles and common pitfalls. *Nephrology Dialysis Transplantation, 25*(5), 1388-1393. doi: 10.1093/ndt/gfp732

Perneger, T. V. (1998). What’s wrong with Bonferroni adjustments. *British Medical Journal, 316*(7139), 1236-1238.

Pincus, T., Burton, A. K., Vogel, S., & Field, A. P. (2002). A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. *Spine, 27*(5), 109-120.

Puentedura, E. J., & Louw, A. (2012). A neuroscience approach to managing athletes with low back pain. *Physical Therapy in Sport, 13*(3), 123-133. doi: 10.1016/j.ptsp.2011.12.001

Punnett, L., Pruss-Utun, A., Nelson, D. I., Fingerhut, M. A., Leigh, J., Tak, S., & Phillips, S. (2005). Estimating the global burden of low back pain attributable to combined occupational exposures. *American Journal of Industrial Medicine, 48*(6), 459-469. doi: 10.1002/ajim.20232

Ramond-Roquin, A., Pecquenard, F., Schers, H., Van Weel, C., Oskam, S., & Van Boven, K. (2015). Psychosocial, musculoskeletal and somatoform comorbidity in patients with chronic low back pain: original results from the Dutch

Transition Project. *Family Practice, 32*(3), 297-304. doi: 10.1093/fampra/cmv027

Reese, C., & Mittag, O. (2013). Psychological interventions in the rehabilitation of patients with chronic low back pain: evidence and recommendations from systematic reviews and guidelines. *International Journal of Rehabilitation Research, 36*(1), 6-12. doi: 10.1097/MRR.0b013e32835acfec

Schmidt, C. P., Zwingenberger, S., Walther, A., Reuter, U., Kasten, P., Seifert, J., . . . Stiehler, M. (2014). Prevalence of low back pain in adolescent athletes - an epidemiological investigation. *International Journal of Sports Medicine, 35*(8), 684-689. doi: 10.1055/s-0033-1358731

Scholich, S. L., Hallner, D., Wittenberg, R. H., Hasenbring, M. I., & Rusu, A. C. (2012). The relationship between pain, disability, quality of life and cognitive-behavioural factors in chronic back pain. *Disability and Rehabilitation, 34*(23), 1993-2000. doi: 10.3109/09638288.2012.667187

Schulz, P., Schlotz, W., & Becker, P. (2004). *TICS - Trierer Inventar zum chronischen Stress* [Trier Inventory for Chronic Stress]. Göttingen: Hogrefe.

Simons, L. E., Elman, I., & Borsook, D. (2014). Psychological processing in chronic pain: a neural systems approach. *Neuroscience and Biobehavioral Reviews, 39*, 61-78. doi: 10.1016/j.neubiorev.2013.12.006

Standaert, C. J., Herring, S. A., & Pratt, T. W. (2004). Rehabilitation of the athlete with low back pain. *Current Sports Medicine Reports*, *3*(1), 35-40.

Storheim, K., & Zwart, J.-A. (2014). Musculoskeletal disorders and the Global Burden of Disease Study. *Annals of the Rheumatic Diseases, 73*(6), 949-950. doi: 10.1136/annrheumdis-2014-205327

Trainor, T. J., & Trainor, M. A. (2004). Etiology of low back pain in athletes. *Current Sports Medicine Reports, 3*(1), 41-46.

Vacha-Haase, T., & Thompson, B. (2004). How to estimate and interpret various effect sizes. *Journal of Counseling Psychology, 51*(4), 473.

Von Korff, M., Ormel, J., Keefe, F. J., & Dworkin, S. F. (1992). Grading the severity of chronic pain. *Pain, 50*(2), 133-149.

Waddell, G. (2006). Preventing incapacity in people with musculoskeletal disorders. *British Medical Bulletin, 77-78*(1), 55-69. doi: 10.1093/bmb/ldl008

Weineck, J. (2009). *Optimales Training [Optimal training]* (16 ed.). Balingen: Spitta Verlag.

Wheeler, A. H., Schneck, M. J., Talavera, F., Halsey, J. H., & Berman, S. A. (2014). Low back pain and sciatica: Pathophysiology. Retrieved March 19, 2015, from http://emedicine.medscape.com/article/1144130-overview#aw2aab6b3

Wiech, K., Ploner, M., & Tracey, I. (2008). Neurocognitive aspects of pain perception. *Trends in Cognitive Sciences, 12*(8), 306-313. doi: 10.1016/j.tics.2008.05.005

Williams, J. M., & Andersen, M. B. (2007). Psychosocial antecedents of sport injury and interventions for risk reduction. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of sport psychology* (pp. 379-403). Hoboken, NJ: John Wiley & Sons, Inc.

Acknowledgements

The present study was initiated and funded by the German Federal Institute of Sport Science (IIA1–080102B/11–14). The research was realized within MiSpEx – The National Research Network for Medicine in Spine Exercise.

Highlights for article

Parameters of low back pain chronicity among athletes:

Associations with physical and mental stress

- Low back pain (LBP) chronification is associated with stress in athletes
- Physical stress plays a predominant role for athletes' perceived pain
- The findings pronounce the value of biopsychosocial approaches for LBP in athletes
- Monitoring of athletes' stress seems to be important to prevent chronic LBP