Diagnosis of psychosocial risk factors in prevention of low back pain in athletes (MiSpEx)

Pia-Maria Wippert,1 Anne-Katrin Puschmann,1 Adamantios Arampatzis,2 Marcus Schiltenwolf,3 Frank Mayer4

ABSTRACT
Background Low back pain (LBP) is a common pain syndrome in athletes, responsible for 28% of missed training days/year. Psychological factors contribute to chronic pain development. This study aims to investigate the transferability of psychosocial screening tools developed in the general population to athletes and to define athlete-specific thresholds.

Methods Data from a prospective multicentre study on LBP were collected at baseline and 1-year follow-up (n=52 athletes, n=289 recreational athletes and n=246 non-athletes). Pain was assessed using the Chronic Pain Grade questionnaire. The psychosocial Risk Stratification Index (RSI) was used to obtain prognostic information regarding the risk of chronic LBP (CLBP). Individual psychosocial risk profile was gained with the Risk Prevention Index – Social (RPI-S). Differences between groups were calculated using general linear models and planned contrasts. Discrimination thresholds for athletes were defined with receiver operating characteristics (ROC) curves.

Results Athletes and recreational athletes showed significantly lower psychosocial risk profiles and prognostic risk for CLBP than non-athletes. ROC curves demonstrated very good sensitivity (RSI=100%; RPI-S: 75%–100%) and specificity (RSI: 76%–93%; RPI-S: 71%–93%). RSI revealed two risk classes for pain intensity (area under the curve (AUC) 0.92(95% CI 0.85 to 1.0)) and pain disability (AUC 0.88(95% CI 0.71 to 1.0)).

Conclusions Both screening tools can be used for athletes. Athlete-specific thresholds will improve physicians’ decision making and allow stratified treatment and prevention.

INTRODUCTION
With a prevalence of 18%, chronic low back pain (cLBP) is one of the most common pain syndromes in the general population in Europe.1,2 The lifetime prevalence of non-specific low back pain (LBP) is between 51% and 84%.3,4 The majority of patients report pain relief within 1 year, but 24%–80% experience pain recurrence and 8% develop chronic pain.1,2 cLBP is especially detrimental for athletes, limiting their performance and putting them at risk of early retirement from sport. Up to 28% of training days may be missed per year due to LBP, with a 12-month prevalence of 39% and a lifetime prevalence of 60%,5 depending on the sports.6 Since there is often no explicit pathology found in the development of chronic non-specific pain, current guidelines credit a multifactorial aetiology, which includes the significant influence of psychosocial risk factors.7,8

These so-called ‘flag factors’ are related to cognitive beliefs (eg, fear of pain, avoidance strategies and endurance), emotional states (eg, anxiety and depression) and distress and social context (eg, social support and healthcare context). The flag factors are colour coded—red, yellow, blue, black and orange flags—depending on the strength of their influence on developing chronic LBP, whereby the yellow flags are the most well known. Although it is known that flag factors influence the development of chronic LBP,
they are still underused in clinics. Methodologically simple screening instruments to support prevention and diagnosis are still scarce.

Until now, screening instruments designed for primary care settings have either classified patients with LBP into risk groups (eg, Heidelberg Short Early Risk Assessment Questionnaire for the Prediction of Chronicity in Low Back Pain, HKF-R13) and the classification system for case complexity—INTERMED—have aimed to predict future LBP chronication risk based on the presence of yellow flags (eg, Risk Screening of Back Pain, RISC-BP15, Prognostic Model, PICKUP16, 17 and Örebro Musculoskeletal Pain Screenings Questionnaire (ÖMPSQ)). Only one tool allows both a prognosis of pain chronication risk and a stratified allocation to risk and treatment groups (STaR Back DEscription Tool, SBDT). However, all of these instruments share one problem when it comes to working with athletes: they were validated within patient populations and therefore not applicable when recommending secondary preventions or exercise treatment settings that is essential for athletes’ affairs.

To date, there is no LBP flag factor screening specifically validated for athletes. Athletes have different lifestyles and healthcare needs compared with the general population. The effects of an athlete’s daily training routine and the influence of athletic training on pain perception and processing should be taken into account when estimating psychosocial risk factors for chronic pain and developing individualised treatment and prevention strategies. Two recently published screening tools, the Risk Stratification Index (RSI) and the Risk Prevention Index—Social (RPI-S), seem promising for use with athletes. While the psychosocial RSI supplies a 1-year prognosis of chronic pain risk, the psychosocial RPI identifies individual risk profiles and the Risk Prevention Index—Social (RPI-S) seem promising for use with athletes. While the psychosocial RSI supplies a 1-year prognosis of chronic pain risk, the psychosocial RPI identifies individual risk profiles and the Risk Prevention Index—Social (RPI-S) seem promising for use with athletes.

The objectives of this study were therefore (1) to evaluate the transferability of the RSI and RPI-S to athlete populations, (2) to determine if regular athletes demonstrated different risk index and profiles in comparison with recreational and non-athletes and (3), if necessary, to define optimal classification thresholds for regular athletes.

**METHODS**

**Subjects**

Athletes and non-athletes between the ages of 18 and 65 years were recruited for study participation and included if they fulfilled the following criteria: at least one episode (≥ 4 days) of non-specific LBP in the last 12 months and able to understand and to answer a questionnaire without help. Exclusion criteria were: acute back pain within the last 7 days, pregnancy, inability to stand and inability to fill in a questionnaire independently. All subjects were informed verbally and in writing about the contents of the study. All gave their written informed consent.

**Instruments**

**Chronic Pain Grade questionnaire (CPG)**

Pain was assessed using the CPG, which indicates characteristic pain intensity (CP: 0=‘no pain’ to 100=‘strongest imaginable pain’) and subjective pain disability (DISS: 0=‘no disability’ to 100=‘inability to do anything’) within the last 3 months.

**Risk Stratification Index**

The 1-year prognosis of the individual risk for developing chronic pain was assessed by the psychosocial RSI. This index (total of 21 items) is analysed in an 8-item scale for the prediction of future pain disability and in a 17-item scale for future pain intensity based on CPG values. Greater RSI scores assume that psychosocial risk factors facilitate chronic pain development after LBP episode or injury and would recommend a deeper look into the risk profiles of the affected persons.

**Risk Prevention Index—Social**

A risk profile was obtained by the RPI-S. This index captures the individual psychosocial risk profile in four flag domains (RPI-S#: pain experience: 15 items; RPI-S#: distress: 16 items; RPI-S#: social environment: 20 items; RPI-S#: medical environment: 8 items). Identifying individual needs for stratified care allocation, the RPI-S supports the clinical decision making while offering an estimation about the treatment response sensitivity. This enables healthcare providers and physicians for a selection of optimal therapy components.

**Study procedures**

Data were obtained at baseline and at 1-year follow-up of a 2-year prospective multicentre study on cLBP (MiSpEx Network, design see ref 28). Five clinics participated in the study, which consisted of seven measurement points in the 24-month period (M1=baseline, M2=1 month, M3=3 months, M4=6 months, M5=12 months, M6=18 months and M7=24 months). Psychosocial data were collected using a web-based questionnaire. Furthermore, anthropometric data, pre-existing acute and chronic spine problems, treatments to date, medical record and physical condition were all assessed and noted by physicians.

**Statistical analysis**

Data processing of the questionnaire was based on the CPG manual: RSI and RPI-S scales were summed up descriptively using the given regression weightings (IBM SPSS V.24.0). Between-group differences were analysed using general linear models (GLM) with planned contrasts (P<0.05). All analyses were controlled for age. Finally, optimal discrimination thresholds for risk subgroups were calculated by receiver operating characteristics (ROC) curves. Cut-offs were established with the Youden’s Index. The range definitions of ‘acceptable’
Table 1  Descriptive statistics (M, SD) and group differences calculated using GLM with age as a covariate

| Characteristic | G1: non-athletes | G2: recreational athletes | G3: regular athletes | Analysis of group differences |
|----------------|------------------|---------------------------|---------------------|------------------------------|
|                | <3 hours PA/week | 3–10 hours PA/week        | >10 hours PA/week   |                               |
| n              | M    | SD   | n    | M    | SD   | n    | M    | SD   | df | F    |
| Subjective disability (DISS) | | | | | | | | | | |
| RSI-S          | 223  | 13.6 | 11.7 | 266  | 8.5  | 9.2  | 48   | 8.3  | 10.4 | 3,533 | 29.76** |
| RPI-SP         | 237  | 13.1 | 8.6  | 279  | 8.8  | 6.4  | 51   | 7.4  | 6.4  | 3,563 | 45.54** |
| RPI-SS         | 198  | 11.2 | 8.1  | 222  | 8.1  | 6.9  | 39   | 9.1  | 8.0  | 3,455 | 28.35** |
| RPI-SSE        | 174  | 12.4 | 10.3 | 214  | 9.7  | 7.9  | 36   | 10.3 | 9.2  | 3,420 | 18.10** |
| RPI-SME        | 209  | 12.2 | 8.6  | 230  | 9.1  | 7.1  | 39   | 8.9  | 8.3  | 3,474 | 29.43** |
| Analysis of group differences | | | | | | | | | | |
| Characteristic pain intensity (CPI) | | | | | | | | | |
| RSI-S          | 232  | 25.4 | 13.0 | 274  | 18.8 | 11.9 | 50   | 18.1 | 14.3 | 3,552 | 20.30** |
| RPI-SP         | 226  | 26.2 | 11.8 | 267  | 20.2 | 10.8 | 48   | 18.1 | 11.9 | 3,537 | 24.45** |
| RPI-SS         | 240  | 24.8 | 11.7 | 280  | 19.4 | 10.6 | 51   | 17.9 | 12.5 | 3,567 | 21.79** |
| RPI-SSE        | 209  | 25.9 | 11.9 | 261  | 19.8 | 11.0 | 48   | 17.6 | 11.4 | 3,528 | 20.97** |
| RPI-SME        | 245  | 24.7 | 10.8 | 287  | 19.5 | 10.0 | 52   | 18.3 | 10.6 | 3,580 | 23.25** |

Group differences calculated with planned contrasts. n_total=588 (9% regular athletes, 49% recreational athletes and 42% non-athletes). GLMs, analyses of contrasts, statistically significant contrasts are reported.

*P<0.05; **P<0.01.

GLM, general linear model; PA, physical activity/exercise training; RSI, Risk Stratification Index; RPI, Risk Prevention Index—Social; RPI-Sme, medical environment; RPI-Spe, pain experience; RPI-Sde, distress; RPI-Sel, socialenvironment.
RESULTS
Sample
At baseline, n=1071 participants were enrolled and completed the initial questionnaire. Of those, n=677 (65%) completed questionnaires at 1-year follow-up. Complete data sets for the presented calculation were available for n=588 (age: M=39 years, SD=13 years, f=57.5%). Drop-outs were mostly due to upcoming pregnancy, illness or relocation. Differences between participants who completed and those who did not were not observed. Participants were categorised depending on physical activity (PA), resulting in three groups: n=52: regular athletes (PA >10 hours training/week; age: M=29 years, SD=10 years), n=289: recreational athletes (PA: 3–10 hours training/week; age: M=38 years, SD=13 years) and n=246: non-athletes (PA: <3 hours training/week; age: M=42 years, SD=13 years).

Descriptives and differences
Statistically significant group differences were observed for age (F(2, 584)=23.74, P<0.01), but not for gender. RSI: regular athletes and recreational athletes revealed a significantly lower psychosocial risk index of developing chronic pain after 1-year compared with non-athletes (P<0.01). This applied to both GLM calculations, CPI (F(3, 552)=20.30, P<0.01) and pain disability (DISS) (F(3, 552)=29.76, P<0.01).

RSI-S: These findings remained consistent for the CPI risk profiles across the four risk domains (pain experience: RPI-Sp; distress: RPI-Ss; social environment: RPI-SSE; medical environment: RPI-SMC; P<0.01; see table 1). For DISS, regular athletes and recreational athletes showed significantly lower risk values than non-athletes in the domain pain experience (RPI-Sp; P<0.01). Solely in the profile domains, distress and social environment showed regular athletes with significantly higher risk values than recreational athletes (RPI-Ss; P=0.019; RPI-SSE; P=0.012).

Discriminant validity
RSI: The cut-off for the pain intensity index of the highest risk group was 32 points (subgroup 3: risk for CPI of >50 after 1 year, table 2) with 100% sensitivity and 93% specificity. A negative likelihood ratio (LR) of 0.00 and a positive likelihood ratio of 14.99 suggest substantial support in clinical decision making. For pain disability, only one cut-off was calculable with 80% sensitivity and 93% specificity (LR− 0.22 up to LR+ 11.43).

RSI-S: The sensitivities of risk profiles and stratified treatment allocation were between 75% and 100% and specificity between 71% and 93%. The negative likelihood ratios ranged from 0.00 to 0.35 for pain intensity and from 0.00 to 0.29 for pain disability, indicating small differences. Positive LR for pain intensity ranged from 2.63 to 14.99, and for pain disability from 2.00 to 11.43, indicating moderate differences and substantial aid for clinical decision making (see table 3A,B). Disability calculations of sensitivity and specificity were only possible for subgroup 1 (lowest risk) due to low sample sizes in the higher risk groups.

The discriminant validity for the 1 year prognosis of the RSI differentiated two risk classes and performed very well (pain intensity: area under the curve (AUC) 0.92 (95% CI 0.85 to 1.0) and pain disability: AUC 0.88

Table 2 Subgroups and CPG scale points (0–100) for regular athletes

| Risk subgroups | CPG points (scale range 0–100) | CPI | DISS |
|----------------|---------------------------------|-----|------|
| 1. Low risk    | 0–29                            | 39  | 46   |
| 2. Medium risk | 30–49                           | 8   | 4    |
| 3. High risk   | 50–69                           | 3   | 0    |
| 4. Very high risk | 70–100                        | 1   | 1    |

CPI, characteristic pain intensity; DISS, subjective pain disability

Table 3 Sensitivity, specificity, negative and positive likelihood ratios (LR) for RSI and RPI-S generated with Youden’s Index

| A) Subgroups | Cut-off values | Sensitivity % | Specificity % | Negative LR | Positive LR |
|--------------|----------------|---------------|---------------|-------------|-------------|
| RSI ≥22      | 100            | 76            | 0.00          | 4.22        |
| RSI ≥32      | 100            | 93            | 0.00          | 14.99       |
| RPI-SSE ≥21  | 75             | 71            | 0.35          | 2.63        |
| RPI-SSE ≥32  | 75             | 91            | 0.28          | 8.06        |
| RPI-SS ≥19   | 83             | 74            | 0.23          | 3.17        |
| RPI-SS ≥28   | 100            | 89            | 0.00          | 9.09        |
| RPI-SP ≥21   | 91             | 86            | 0.11          | 6.54        |
| RPI-SP ≥29   | 100            | 93            | 0.00          | 14.29       |
| RPI-SMC ≥22  | 83             | 82            | 0.20          | 4.64        |
| RPI-SMC ≥24  | 100            | 77            | 0.00          | 4.27        |

| B) Subgroups | Cut-off values | Sensitivity % | Specificity % | Negative LR | Positive LR |
|--------------|----------------|---------------|---------------|-------------|-------------|
| RSI ≥19      | 80             | 93            | 0.22          | 11.43       |
| RPI-SSE ≥8   | 80             | 73            | 0.27          | 2.96        |
| RPI-SS ≥9    | 100            | 67            | 0.00          | 3.03        |
| RPI-SP ≥6    | 100            | 50            | 0.00          | 2.00        |
| RPI-SMC ≥9   | 80             | 70            | 0.29          | 2.67        |

Negative/positive likelihood ratio of 0.2–0.5/2–5=small difference, relevant for clinical decision making; 0.1–0.2/5–10=moderate difference, substantial for clinical decision making; <0.1/10=clinical important difference, highest test quality. Due to small sample sizes, cut-offs for only one group was calculated. Calculations based on CPG Scale Characteristic Pain Intensity (CPI), n=51.

CPG, Chronic Pain Grade questionnaire; RSI—Risk Stratification Index; RPI, Risk Prevention Index—Social; RPI-Sp, pain experience; RPI-Ss, distress; RPI-SSE, social environment; RPI-SMC, medical environment.
Table 4 Discriminant validity: AUC for risk subgroups based on CPG scales characteristic pain intensity (CPI) and subjective pain disability (DISS)

| Risk subgroups  | CPI (95% CI) | DISS (95% CI) |
|-----------------|--------------|---------------|
| RSI 1 vs 2/3/4  | 0.92 (0.85 to 1.0) | 0.88 (0.71 to 1.0) |
| 1/2 vs 3/4      | 0.97 (0.93 to 1.0) | 0.48 (0.33 to 0.62) |
| RPI-SSE 1 vs 2/3/4 | 0.82 (0.70 to 0.95) | 0.71 (0.50 to 0.91) |
| 1/2 vs 3/4      | 0.90 (0.71 to 1.0) | 0.44 (0.27 to 0.61) |
| RPI-SS 1 vs 2/3/4 | 0.90 (0.80 to 0.99) | 0.85 (0.70 to 1.0) |
| 1/2 vs 3/4      | 0.97 (0.92 to 1.00) | 0.65 (0.49 to 0.80) |
| RPI-SP 1 vs 2/3/4 | 0.93 (0.85 to 1.0) | 0.77 (0.56 to 0.99) |
| 1/2 vs 3/4      | 0.98 (0.94 to 1.0) | 0.36 (0.19 to 0.46) |
| RPI-SMC 1 vs 2/3/4 | 0.87 (0.76 to 0.98) | 0.69 (0.45 to 0.94) |
| 1/2 vs 3/4      | 0.91 (0.80 to 1.0) | 0.20 (0.07 to 0.33) |
| 1/2/3 vs 4      | –             | –              |

RSI, Risk Stratification Index as well as RPI, Risk Prevention Index—Social; RPI-Sp, pain experience; RPI-SS, distress; RPI-SSE, social environment; RPI-SMC, medical environment.

(95% CI 0.71 to 1.0). The discriminant validity for the risk profile (RPI-S) in the first subgroup revealed AUCs ranging between 0.82 and 0.93 for pain intensity and between 0.69 and 0.85 for pain disability (see Table 4).

DISCUSSION
We evaluated the transferability of the psychosocial RSI and RPI-S to athletes, to investigate differences in prognostic risk index and risk profiles between regular and recreational athletes as well as non-athletes, and then, if necessary, to define optimal classification thresholds for regular athletes.

Transferability
Both screening instruments (RSI and RPI-S) can accurately and reliably be transferred to regular athletes. The psychosocial RSI provides a precise estimation of the expected individual CPG pain intensity and disability value for a regular athlete up to 1 year later. With eight questions and clear discrimination thresholds,34 the RSI offers physicians an insight into the chronic pain disability risk of their athletes. The discrimination validity outperforms standardised instruments in the general population (eg, PICKUP,18 STarT-Back21 and OMPSQ20. The psychosocial RPI also provides physicians with insight into the psychosocial risk profile of their athletes and allows them to personalise treatment decisions with strong likelihood ratios that suggest a substantial improvement in clinical decision making, as requested in modern concepts of secondary prevention.9 32

Group differences
Regarding differences between groups, regular athletes and recreational athletes both displayed lower psychosocial prognostic risk indices of developing chronic LBP, and furthermore, lower psychosocial risk profiles compared with non-athletes. These results extend epidemiological data showing lower LBP lifetime prevalence in athletes5 than in the general population.3 4 Possible explanations are benefits due to a physically active lifestyle, social integration in sport clubs and training adaptation effects in skeletal muscles. Also, athletes receive different healthcare management than does the general population, with more frequent and regular check-ups.23 24 Athletes may, in addition, continue engaging in PA despite acute pain.33

Another point, recently discussed in a meta-analysis,25 is that regular athletes may have a greater pain tolerance compared with the general population. However, available data on pain thresholds are less convincing. Further explanations touted are that somatosensory processing in regular athletes differs due to a less responsive endogenous pain inhibitory system26 or that exercise reduces pain due to an exercise-induced hypoalgesia (EIH).27 34 However, greater stress exposure (eg, stress analgesia) leads to maladaptations of this EIH and to pain sensitisation35 as it has been observed in former soldiers.36 Although, the complete aetiology has yet to be clarified, our data confirm the higher stress risk profiles for pain disability in regular athletes but lower overall risk values. This was also expected with regards to pain intensity, but no such evidence was found. It is evident that increasing training volumes, travel times and media tasks within an international competition schedule boost the distress and social environment. Hence, increasing risk profiles between regular and recreational athletes both displayed lower psychosocial and subjective pain disability as requested in modern concepts of secondary prevention.9 32

Limitations
Limiting factors of the study, which must be considered, are: (1) the small sample sizes and the imprecise nature of lower back pain prevalence calculations among athletes, in which for our purposes were estimated based on the total sample. The prevalence in athletes of CPG-CPI ≥50 was 7% within the entire sample, which indeed corresponds with prevalence literature of persistent, non-specific lower back pain in the general population.1 2 (2) The small number of athletes with chronic back pain in a higher CPG grades (especially related to DISS), which further limited the analysis and results and should be replicated in other samples. (3)
The length of the screening instrument seemed appropriate, but the full RPI-S (for all risk profiles) can reach up to 50 questions.

SUMMARY

The RSI is the first screening tool allowing an exact estimation of athletes’ psychosocial risk of developing chronic LBP and their potential pain experience within 1 year. The RPI-S describes athletes’ psychosocial risk profiles in four flag domains and the specific needs of additional psychosocial treatment in addition to the usual medical, manual or exercise treatment. This auspicious opportunity may support a specified type and dosage of training therapy resulting in quicker rehabilitation after LBP episodes for regular athletes. This essential question is currently being further analysed in two randomised controlled exercise treatment studies of the MiSpEx network.

Acknowledgements

We would like to thank Sören Matzk, Heather Williams, Michael Rector, Heidrun Beck, Hendrik Schmidt, Karsten Dreinhöfer, Georg Duda, Nico Streich and Philip Kasten. The authors would also like to thank both the technical and medical staff from the study sites for their contributions throughout the study.

Contributors

All authors substantially contributed to the conception and realisation of the studies. PMW wrote the first draft of the manuscript and all authors critically revised the manuscript for important intellectual content. PW was responsible for methodological design and analysis related to all psychosocial factors; PMW, AKP and MS provided scientific and practical information for the psychosocial content. AKP provided the statistical analysis and information. AA and FM provided all scientific information for biomechanical and medical content. FM conceived of the study as principal investigator. All authors read and approved the final manuscript.

Funding

The present study was funded by the German Federal Institute of Sport Science on behalf of the Federal Ministry of the Interior of Germany. It was realised within MiSpEx – the National Research Network for Medicine in Spine Exercise (grant-number: 09P1032A/11-14). All sources of funding for the research reported are declared. The funder did not influence data collection, analysis, interpretation or writing of the manuscript.

Competing interests

None declared.

Patient consent

Obtained.

Ethics approval

Ethics approval from the University of Potsdam, Germany (number 36/2011).

Provenance and peer review

Not commissioned; internally peer reviewed.

Open Access

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, subject to the conditions of the licence. See: http://creativecommons.org/licenses/by-nc/4.0/ © Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2017. All rights reserved. No commercial use is permitted unless otherwise expressly granted.
27. Ellingson LD, Koltyn KF, Kim JS, et al. Does exercise induce hypoalgesia through conditioned pain modulation? *Psychophysiology* 2014;51:267–76.

28. Wippert P-M, Puschmann A-K, Drießlein D, et al. Development of a risk stratification and prevention index for stratified care in chronic low back pain. Focus: yellow flags (MiSpEx Network). *PAIN*® Reports. *Pain Rep* 2017;1.

29. Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. *Pain* 1992;50:133–49.

30. Youden WJ. Index for rating diagnostic tests. *Cancer* 1950;3:32–5.

31. Metz CE. Basic principles of ROC analysis. *Semin Nucl Med* 1978;8:283–98.

32. Burton AK, McClune TD, Clarke RD, et al. Long-term follow-up of patients with low back pain attending for manipulative care: outcomes and predictors. *Man Ther* 2004;9:30–5.

33. Derroche T, Woodman T, Stephan Y, et al. Athletes’ inclination to play through pain: a coping perspective. *Anxiety Stress Coping* 2011;24:579–87.

34. Koltyn KF, Brellenthin AG, Cook DB, et al. Mechanisms of exercise-induced hypoalgesia. *J Pain* 2014;15:1294–304.

35. Wippert PM, Wiebking C. [Adaptation to physical activity and mental stress in the context of pain: Psychobiological aspects]. *Schmerz* 2016;30:429–36.

36. Cook DB, Stegner AJ, Ellingson LD. Exercise alters pain sensitivity in Gulf War veterans with chronic musculoskeletal pain. *J Pain* 2010;11:764–72.

37. Hill DW, Hill CM, Fields KL, et al. Effects of jet lag on factors related to sport performance. *Can J Appl Physiol* 1993;18:91–103.

38. Samuels CH. Jet lag and travel fatigue: a comprehensive management plan for sport medicine physicians and high-performance support teams. *Clin J Sport Med* 2012;22:268–73.

39. Wippert PM, de Witt Huberts J, Klipker K, et al. [Development and content of the behavioral therapy module of the MiSpEx intervention: Randomized, controlled trial on chronic nonspecific low back pain]. *Schmerz* 2015;29:658–63.

40. Niederer D, Vogt L, Wippert PM, et al. Medicine in spine exercise (MiSpEx) for nonspecific low back pain patients: study protocol for a multicentre, single-blind randomized controlled trial. *Trials* 2016;17:507.