

Clinical Pain Research

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Psychosocial subgroups in high-performance athletes with low back pain: eustress-endurance is most frequent, distress-endurance most problematic!

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Abstract

Objectives: In non-athletes, fear-avoidance and endurance-related pain responses appear to influence the development and maintenance of low back pain (LBP). The avoidance-endurance model (AEM) postulates three dysfunctional pain response patterns that are associated with poorer pain outcomes. Whether comparable relationships are present in athletes is currently unclear. This cross-sectional case-control study explored frequencies and behavioral validity of the AEM-based patterns in athletes with and without LBP, as well as their outcome-based validity in athletes with LBP.

Methods: Based on the Avoidance-Endurance Fast-Screen, 438 (57.1% female) young adult high-performance athletes with and 335 (45.4% female) without LBP were categorized as showing a “distress-endurance” (DER),

“eustress-endurance” (EER), “fear-avoidance” (FAR) or “adaptive” (AR) pattern.

Results: Of the athletes with LBP, 9.8% were categorized as FAR, 20.1% as DER, 47.0% as EER, and 23.1% as AR; of the athletes without LBP, 10.4% were categorized as FAR, 14.3% as DER, 47.2% as EER, and 28.1% as AR. DER and EER reported more pronounced endurance- and less pronounced avoidance-related pain responses than FAR, and vice versa. DER further reported the highest training frequency. In athletes with LBP, all dysfunctional groups reported higher LBP intensity, with FAR and DER displaying higher disability scores than AR.

Conclusions: The results indicate that also in athletes, patterns of endurance- and fear-avoidance-related pain responses appear dysfunctional with respect to LBP. While EER occurred most often, DER seems most problematic.

Implications: Endurance-related pain responses that might be necessary during painful exercise should therefore be inspected carefully when shown in response to clinical pain.

Keywords: athletes; disability; endurance; fear-avoidance; pain; pain responses.

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Introduction

With 12-month prevalence rates between 35 and 63%, athletes are similarly or possibly even more affected by low back pain (LBP) as non-athletes [1–5], leading to considerable losses of training or playing time [6]. In non-athletes, psychosocial variables such as pain catastrophizing, fear-avoidance beliefs and depressive mood [7–11], and endurance-related pain responses with pronounced task persistence despite pain [7, 12, 13] seem to influence the course of recovery. Corresponding research in athletes, however, is required to improve the understanding of clinical pain beyond sports-related injury [14].

The avoidance-endurance model (AEM) postulates three dysfunctional pain response patterns which facilitate the chronicity of musculoskeletal pain [15, 16]. Distress-endurance responses (DER) are characterized by pronounced pain-related thought suppression, the attempt to simply not think on pain [15, 16]. As thought suppression is often ineffective, it may be accompanied by depressive mood [17–21]. Eustress-endurance responses (EER), in contrast, comprise cognitions of focused distraction from pain that succeed more often and are associated with positive mood [22, 23]. Both endurance patterns share the feature of task persistence despite severe pain, presumably resulting in an overuse of physical structures [24]. Fear-avoidance responses (FAR) include catastrophizing, fear of pain, and the avoidance of pain-exacerbating activities, the latter potentially leading to muscular disuse [15, 16]. The AEM further describes an adaptive (AR) pattern with a healthy balance between activity and rest [15, 16]. AEM-based subgroups can be detected by different psychosocial screenings, such as the Avoidance-Endurance Fast-Screen (AE-FS) [25, 26]. In non-athletes with LBP, increased pain ratings have been reported for those subgroups showing a dysfunctional pain response pattern [7, 12, 13, 27], with higher levels of accelerometer-assessed daily-life activity in DER and EER compared to FAR or AR [12, 28]. However, it is unclear whether these AEM-based subgroups also exist in athletes with LBP, and whether their outcome-based validity is given, as demonstrated by poorer pain and disability outcomes in the dysfunctional groups.

During training and competitions, or due to injuries [29–31], athletes are regularly exposed to pain [32]. The development of endurance-related pain responses might therefore be particularly important to maintain or increase their level of performance [33, 34]. Indeed, “playing through” pain [35, 36] or “playing hurt” [37, 38] appear to be common characteristics among athletes, and some studies demonstrated more endurance-related strategies in athletes compared to non-athletes [39, 40], although others reported no such differences [41–43]. One disadvantage of these studies is, however, that they do not distinguish between more complex patterns of pain responses. Knowledge about the frequency of dysfunctional patterns is necessary to determine the number of athletes with clinical pain who may benefit from psychosocial treatment modules. Furthermore, aspects of behavioral validity are of interest, i.e. to investigate whether the AEM-based subgroups differ in their regular training frequency or other measures of avoidance and endurance to prevent a reduction in performance due to clinical pain.

The purposes of this cross-sectional study were therefore to explore (a) frequencies and (b) aspects of behavioral

validity of AEM-based patterns in athletes with LBP compared to LBP-free controls. Based on previous research, the endurance patterns were expected to occur most frequently. Concerning behavioral validity, athletes with a DER or EER pattern were expected to show lower avoidance and higher training frequency, irrespective of the presence of LBP. Furthermore, (c) regarding outcome-based validity in the sample of athletes with LBP, we hypothesized that the dysfunctional subgroups displayed poorer outcomes compared to AR.

Materials and methods

Study sample and procedure

The current cross-sectional case-control study was part of a larger study investigating the effects of demographic, sports-related and psychosocial variables on back pain in German high-performance athletes. Data were obtained using a computer-based questionnaire format. Information on the objectives of the study and a hyperlink to the online survey were sent via email to the approximately 4,000 high-performance athletes included in the database by the German Olympic Sports Confederation. High-performance athletes were defined as athletes at the highest German competition level who were members of their federal sports association or participants in the first or second national divisions of their discipline. According to their age group and performance level, they belonged to A- (federal level, national teams), B- (potential to join the national team), C- or D-squads (excellent new talents; junior-age athletes).

Athletes were included in the current investigation if they had experienced LBP during the last three months, and if they were between 18 and 35 years of age. The lower limit of 18 years was selected as the AEM has been tested primarily in adult populations [7, 12, 13, 27], and due to some evidence that certain pain coping strategies change as a function of age [44] or that there are age-related differences in the impact of pain coping on pain outcomes [45, 46]. The upper limit enhances comparability with previous studies in athletes [47, 48].

All participants gave their informed and written consent. The study was approved by the German Olympic Sports Confederation as well as the local ethics committee and conducted in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Patient and public involvement statement

There was no direct patient and public involvement in this study.

Measures

Demographics and pain history. Sex, age, stage of sporting season, total LBP duration and pain comorbidities during the last three months were obtained with a general demographic and pain history checklist. LBP duration was categorized as “1–7 days”, “8–30 days”, “more than 30 days, but not every day”, and “everyday”.

Depression. Depression was measured using the German version [49] of the Beck Depression Inventory for Primary Care (BDI-PC), a self-report questionnaire that comprises seven items assessing cognitive and affective responses associated with depression [50]. The sum score ranges from 0 to 21 and displays an index of depressive symptom severity, with higher scores representing higher levels of depressive symptoms. Its psychometric properties have been thoroughly investigated [51].

Psychosocial pain responses. Psychosocial pain responses were assessed using the Avoidance-Endurance Questionnaire (AEQ) [52], a 49-item self-report questionnaire measuring endurance- and avoidance-related cognitive, affective and behavioral responses to acute pain. The AEQ comprises four endurance-related (positive mood despite pain, thought suppression, humor/distraction, pain persistence) and five avoidance-related subscales (anxiety/depression, help-/hopelessness, catastrophizing thoughts, avoidance of social activities, and avoidance of physical activities). Patients are instructed to rate on a 7-point scale from “0” (never) to “6” (always) how often they have experienced specific endurance- or avoidance-related thoughts and actions during the last two weeks. All items addressing behavioral responses are to be answered for the experience of “mild pain” and “severe pain”, respectively, the latter used in this study. Mean scores of the respective items are calculated separately for each subscale. High validity and reliability (Cronbach’s $\alpha=0.76\text{--}0.91$) have been demonstrated for all subscales [52].

Pain and disability measures. LBP intensity and pain-related disability during the preceding three months were assessed by the Chronic Pain Grade [53], a 7-item self-administered questionnaire measuring the severity of chronic pain. The two resulting scores – the Characteristic Pain Intensity and the Disability Score – range from 0 to 100, with higher scores reflecting higher levels of LBP intensity or pain-related disability, respectively. For the Characteristic Pain Intensity – a score integrating present pain intensity as well as worst and average pain intensity during the last three months – good validity and moderate internal consistency (Cronbach’s $\alpha=0.68$) have been demonstrated. The Disability Score depicts the overall functional disability with respect to daily, social and work activities and has been shown to be a valid and reliable measure (Cronbach’s $\alpha=0.88$) [54]. Training- and competition-related disability were measured using corresponding questions (“In the last three months, how much has your back pain interfered with your high-performance training?”, “In the last three months, how much has your back pain interfered with your participation in high-performance competitions?”) with a range from 0 (“no interference”) – 100 (“unable to carry on any activities”).

Training frequency. Training frequency was assessed by asking how many hours per week, on average, a participant was engaged in sports activities including competitions, regeneration, gymnastics etc.

Classification of AEM-based patterns

Patterns were classified using the AE-FS [25]. This short screening tool is based on the 7-item Pain Persistence Scale (PPS; e.g., “When I am in pain, I carry on doing what I am doing no matter what.”) from the AEQ [52] and the item “loss of pleasure” from the German version [49] of the BDI-PC [50]. PPS scores greater than or equal to the mean scale score of 3 indicate that an athlete’s pain responses occurred “sometimes”, “often”, “most of the time” or “always”. Scores lower than 3 indicate that an athlete’s pain responses occurred “seldom”, “almost never” or “never”. Regarding the item “loss of pleasure”, a cut-off score of ≥ 1 has been shown to indicate mild or more severe depression with a sensitivity of 0.77 [26]. Athletes were

labeled as showing a FAR pattern if their loss of pleasure score was ≥ 1 and their PPS score was < 3 , a DER pattern if their loss of pleasure score was ≥ 1 and their PPS score was ≥ 3 ; an EER pattern if their loss of pleasure score was $= 0$ and their PPS score was ≥ 3 , and an AR pattern if their loss of pleasure score was $= 0$ and their PPS score was < 3 . For the AE-FS, adequate validity has been reported regarding the prediction of pain intensity and disability after 6 months in patients with subacute LBP [25].

Statistics

Data preparation and pre-analyses. If data on continuous variables were missing in less than 5% of all cases, they were replaced by the respective mean score of the total sample; if data were missing in more than 5% of all cases, athletes with missing values were excluded from the respective analysis. Data were visually examined using box plots; potential outlier values were checked for plausibility (e.g., errors in data entry). Outcome variables were analysed for (multivariate) normality using the Shapiro–Wilk test and probability-probability plots; yet, in case of non-normally distributed outcome variables, the central limit theorem justifies the normality assumption in analysis of variance (ANOVA) in samples of $n > 30$.

Sample characteristics. Means and standard deviations, or absolute and relative frequencies of sociodemographic, sports-related and pain history variables were calculated separately for athletes with LBP and the LBP-free control group, as appropriate. Potential group differences in sex, age, stage of sporting season and pain comorbidities during the last three months were analysed with Student’s t-test for normally distributed continuous variables, Mann–Whitney U test for non-normally distributed continuous variables, and Pearson chi-square test for categorical variables.

Frequencies of AEM-based patterns and pattern characteristics. Absolute and relative frequencies of AEM-based patterns were generated separately for athletes with LBP and controls. Possible group differences in the proportions of the patterns were compared by means of Pearson chi-square test. To further characterize the AEM-based patterns in athletes with LBP and controls, means and standard deviations, or absolute and relative frequencies of sex proportions, age and (in case of athletes with LBP) pain duration categories were calculated, as appropriate. Possible pattern differences in sex proportions were analysed using Pearson chi-square test. With respect to age, patterns were compared by one-way ANOVA, followed by Student’s t-tests.

Behavioral validity of AEM-based patterns. To examine behavioral validity of the patterns in athletes with LBP and controls, patterns were compared with respect to the other endurance- and avoidance-related psychosocial variables from the AEQ [52] that were not part of the classification, depression, and self-reported training frequency. Following a previous study [7], two separate multivariate analyses of variance (MANOVA) were performed with *pattern* (FAR/DER/EER/AR) and *LBP presence* during the last 3 months (yes/no) as fixed factors, and the endurance- or the avoidance-related variables as dependent variables, respectively. Regarding depression and training frequency, two separate two-factorial ANOVAs were calculated, with *pattern* (FAR/DER/EER/AR) und *LBP presence* during the last three months (yes/no) as between-subjects factors.

Outcome-based validity of AEM-based patterns. Following previous studies [7, 27], a univariate approach was chosen to analyse possible differences between patterns in pain intensity, pain-related disability, training-related disability and competition-related disability [55]. A two-factorial ANOVA was performed for each

outcome variable, with *pattern* (FAR/DER/EER/AR) und *LBP presence* during the last three months (yes/no) as between-subjects factors.

Homoscedasticity was tested using Levene's test; homogeneity of covariance matrices was tested using Box's M test. Pillai's trace was used as the test statistic as it has been shown more robust against violations of normality and homogeneity of covariance matrices [56]. In case of significant main effects or interactions, MANOVA was followed by separate one-way ANOVAs that were followed by Bonferroni-Holm corrected post-hoc t-tests to control for multiple comparisons. The p-values < 0.05 were considered statistically significant. Effect sizes of group effects were calculated as partial eta squared (η_p^2), with $\eta_p^2 \leq 0.06$ representing a small, $\eta_p^2 \leq 0.14$ representing a medium, and $\eta_p^2 \geq 0.14$ representing a large effect [57]; effect sizes for pairwise comparisons were calculated as Cohen's *d*, with $d=0.2$ reflecting a small, $d=0.5$ a medium and $d=0.8$ a large effect [58]. All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS, version 25.0) for Windows.

Results

Sample characteristics

Responses were received from 1.065 athletes, participating in the first or second national divisions and fulfilling an A, B, C, or D grade. 277 athletes were excluded due to age (260 due to age < 18; 15 due to age > 35; two due to missing information on age), nine athletes were excluded due to missing information on LBP presence during the last three months, and seven athletes were excluded due to missing BDI-PC or PPS scores necessary for the classification of the AEM-based patterns, leading to a sample of $n=773$. Various sports disciplines were represented among the remaining sample, with highest percentages found for track and field sports (10.1%), rowing (9.6%), hockey (6.0%), canoeing (4.1%), judo (3.6%), dancing (3.4%), and ice hockey (3.1%).

Three hundred thirty five (43.3%) athletes reported no occurrence of LBP during the last three months, whereas LBP had been present in 438 (56.6%) athletes. Of the latter, 259 (33.5%) had suffered from LBP for 1–7 days, 130 (16.8%) for 8–30 days, and 49 (6.3%) for more than 30 days during the last three months. Athletes with LBP did not significantly differ from the control group in age ($F(1,771)=0.64$, $p=0.423$, $\eta_p^2=0.001$), but in the proportions of sex ($\chi^2(1)=10.46$, $p=0.001$), with a significantly higher female-to-male ratio in athletes with LBP than in the control group. Descriptive data regarding socio-demographic, sports-related and pain history variables for athletes with LBP and controls are summarized in Table 1.

AEM-based patterns in athletes with LBP and controls

Frequencies. Of the athletes with LBP, 43 (9.8%) were categorized as FAR, 88 (20.1%) as DER, 206 (47.0%) as EER,

Table 1: Means ($\pm$ standard deviations) or absolute frequencies (%) for sociodemographic and sports-related variables, separately for athletes with low back pain during the last three months and controls.

Variable	Athletes with LBP (n=438)	Control group (n=335)	Group difference
Female	249 (57.1%)	152 (45.4%)	$p=0.001$
Age	22.08 (3.99)	22.31 (3.99)	n.s.
Stage of sporting season ^a			
General preparation	204 (46.6%)	157 (46.9%)	n.s.
Specific preparation	66 (15.1%)	53 (15.8%)	n.s.
Competition	145 (33.1%)	90 (26.9%)	n.s.
Transition	50 (11.4%)	50 (14.9%)	n.s.
Others	17 (3.9%)	15 (4.5%)	n.s.
Pain comorbidities during the last three months (yes)			
Neck	209 (49.3%)	100 (31.1%)	$p < 0.001$
Shoulders	165 (39.2%)	98 (30.0%)	$p=0.009$
Elbows	55 (13.1%)	18 (5.6%)	$p=0.001$
Wrists/hands	84 (20.1%)	60 (18.5%)	$p=0.579$
Upper back	174 (41.5%)	60 (18.3%)	$p < 0.001$
Hips/thighs	122 (29.2%)	40 (12.4%)	$p < 0.001$
Knees	151 (35.4%)	97 (29.6%)	$p=0.089$
Ankles/feet	115 (27.3%)	64 (19.9%)	$p=0.019$

LBP, Low back pain; p, Level of statistical significance; n.s., Not significant ($p>0.05$). *Note.* Athletes with missing values were excluded from the respective analysis.

^aMultiple answers were possible.

and 101 (23.1%) as AR. Of the control group, 35 (10.4%) were categorized as FAR, 48 (14.3%) as DER, 158 (47.2%) as EER, and 94 (28.1%) as AR. Athletes with LBP and controls did not significantly differ with respect to the proportions of the patterns ($\chi^2(3)=5.54$, $p=0.136$).

The patterns further did not significantly differ with respect to age ($F(3,769)=0.30$, $p=0.827$, $\eta_p^2=0.001$), but regarding the proportions of sex ($\chi^2(3)=11.99$, $p=0.007$), with significantly more women showing an EER pattern, and significantly more men showing an AR pattern ($p's=0.005$). Moreover, in athletes with LBP, there were no pattern differences regarding LBP duration ($\chi^2(3)=12.13$, $p=0.059$).

Behavioral validity. A detailed overview about descriptive statistics as well as the results of the (post-hoc) ANOVAs and significant pairwise comparisons is provided in Table 2.

Endurance-related variables. The MANOVA indicated significant multivariate effects of *pattern* ($V=0.263$, $F(9,2295)=24.54$, $p < 0.001$, $\eta_p^2=0.088$) and *LBP presence* ($V=0.020$, $F(3,763)=5.26$, $p=0.001$, $\eta_p^2=0.020$), but no significant *pattern*LBP presence* interaction ($V=0.008$, $F(9,2295)=0.670$, $p=0.737$, $\eta_p^2=0.003$). Subsequent ANOVAs showed that the AEM-based patterns differed significantly in all endurance-related variables. Post-hoc

Table 2: Behavioral validity of pain response patterns based on the avoidance-endurance model, as analysed by means ($\pm$ standard deviations), one-way (post-hoc) analyses of variance (ANOVA) and Bonferroni-Holm corrected post-hoc t-tests.

Variable	Total sample	DER	EER	FAR	AR	Main effect pattern ^a	Main effect LBP presence ^a	Significant pairwise comparisons ^b
Classification variables								
Loss of pleasure (BDI-PC)								
Athletes with LBP	0.35 (0.57)	1.16 (0.37)	0.00 (0.00)	1.16 (0.37)	0.00 (0.00)	–	–	–
Controls	0.28 (0.52)	1.17 (0.38)	0.00 (0.00)	1.09 (0.28)	0.00 (0.00)			
Pain persistence (AEQ)								
Athletes with LBP	3.39 (1.01)	3.93 (0.66)	3.96 (0.65)	2.19 (0.54)	2.29 (0.57)	–	–	–
Controls	3.12 (1.04)	3.76 (0.60)	3.77 (0.66)	2.17 (0.55)	2.07 (0.71)			
Endurance-related variables (AEQ)								
Thought suppression								
Athletes with LBP	3.28 (1.41)	3.72 (1.28)	3.64 (1.23)	2.39 (1.22)	2.52 (1.47)	$F(3,765)=43.80$ $p < 0.001$ $\eta_p^2=0.147$	$F(1,765)=4.91$ $p=0.027$ $\eta_p^2=0.006$	DER/EER>FAR/AR ($d_{Cohen}=0.83 - 0.95$)
Controls	3.39 (1.46)	3.98 (1.14)	3.77 (1.30)	2.87 (1.47)	2.65 (1.51)			
Humor/Distraction								
Athletes with LBP	2.78 (0.93)	3.02 (0.94)	3.02 (0.85)	2.13 (0.89)	2.34 (0.82)	$F(3,765)=46.26$ $p < 0.001$ $\eta_p^2=0.154$	$F(1,765)=5.86$ $p=0.016$ $\eta_p^2=0.008$	DER/EER>FAR/AR ($d_{Cohen}=0.70 - 1.12$)
Controls	2.62 (1.05)	2.73 (0.96)	3.01 (1.00)	1.85 (0.70)	2.19 (0.98)			
Positive mood despite pain								
Athletes with LBP	3.71 (1.11)	3.69 (1.06)	3.81 (1.06)	3.13 (1.15)	3.75 (1.16)	$F(3,765)=6.77$ $p < 0.001$ $\eta_p^2=0.026$	n.s.	DER/EER/AR>FAR ($d_{Cohen}=0.42 - 0.59$)
Controls	3.81 (1.17)	3.78 (1.03)	3.96 (1.09)	3.38 (1.10)	3.74 (1.35)			
Avoidance-related variables (AEQ)^c								
Anxiety/Depression								
Athletes with LBP	2.11 (1.13)	2.55 (1.14)	1.95 (1.07)	2.70 (1.26)	1.84 (0.99)	$F(3,722)=14.28$ $p < 0.001$ $\eta_p^2=0.056$	n.s.	DER/FAR>EER/AR ($d_{Cohen}=0.51 - 0.64$)
Controls	2.03 (1.24)	2.55 (1.01)	1.91 (1.31)	2.35 (1.12)	1.87 (1.19)			
Help-/Hopelessness								
Athletes with LBP	1.64 (1.07)	2.08 (1.13)	1.49 (0.95)	2.18 (1.30)	1.34 (0.95)	$F(3,722)=10.02$ $p < 0.001$ $\eta_p^2=0.040$	$F(1,722)=10.85$ $p=0.001$ $\eta_p^2=0.015$	DER/FAR>EER/AR ($d_{Cohen}=0.31 - 0.62$)
Controls	1.42 (1.02)	1.72 (0.97)	1.37 (1.04)	1.46 (1.13)	1.33 (0.98)			
Catastrophizing thoughts								
Athletes with LBP	0.56 (0.96)	0.94 (1.33)	0.41 (0.72)	0.90 (1.24)	0.38 (0.73)	$F(3,722)=11.08$ $p < 0.001$ $\eta_p^2=0.044$	n.s.	DER/FAR>EER/AR ($d_{Cohen}=0.39 - 0.55$)
Controls	0.54 (0.84)	0.79 (0.99)	0.43 (0.74)	0.86 (0.87)	0.50 (0.87)			
Avoidance of social activities								
Athletes with LBP	1.77 (1.28)	2.21 (1.33)	1.40 (1.04)	2.33 (1.53)	1.92 (1.35)	$F(3,722)=20.66$ $p < 0.001$ $\eta_p^2=0.079$	$F(1,722)=6.10$ $p=0.014$ $\eta_p^2=0.008$	FAR>DER>AR>EER ($d_{Cohen}=0.20 - 0.91$)
Controls	1.98 (1.31)	2.23 (1.25)	1.71 (1.11)	3.06 (1.53)	1.95 (1.37)			
Avoidance of physical activities								
Athletes with LBP	3.02 (1.12)	2.80 (1.07)	2.81 (0.99)	3.63 (1.06)	3.39 (1.24)	$F(3,722)=27.31$ $p < 0.001$ $\eta_p^2=0.102$	$F(1,722)=19.45$ $p < 0.001$ $\eta_p^2=0.026$	FAR>AR>DER/EER ($d_{Cohen}=0.30 - 0.99$)
Controls	3.40 (1.20)	3.17 (1.14)	3.06 (1.08)	4.37 (0.97)	3.76 (1.21)			

Table 2: (continued)

Variable	Total sample	DER	EER	FAR	AR	Main effect pattern ^a	Main effect LBP presence ^a	Significant pairwise comparisons ^b
Depression (BDI-PC)								
Athletes with LBP	2.10 (2.53)	4.55 (2.75)	1.23 (1.72)	4.32 (3.18)	0.86 (1.36)	$F(3,765)=133.26$ $p < 0.001$ $\eta_p^2=0.343$	n.s.	DER/FAR>EER/AR ($d_{Cohen}=1.51 - 1.68$)
Controls	1.70 (2.35)	4.62 (3.38)	0.93 (1.41)	3.74 (2.12)	0.76 (1.47)			
Training frequency (h/week)								
Athletes with LBP	18.96 (7.87)	22.09 (10.67)	18.58 (6.53)	17.67 (7.43)	17.55 (7.04)	$F(3,765)=5.01$ $p=0.002$ $\eta_p^2=0.019$	n.s.	DER>EER/AR ($d_{Cohen}=0.33 - 0.44$)
Controls	18.33 (8.22)	19.68 (9.99)	18.39 (8.16)	19.24 (7.55)	17.20 (7.49)			

BDI-PC, Beck Depression Inventory for Primary Care; AEQ, Avoidance-Endurance Questionnaire; DER, Distress-endurance pattern; EER, Eustress-endurance pattern; FAR, Fear-avoidance pattern. AR: Adaptive pattern; F , F statistic; p , Level of statistical significance; n.s., Not significant ($p > 0.05$); η_p^2 , Effect sizes of group effects were calculated as partial eta squared, with $\eta_p^2 \leq 0.06$ representing a small, $\eta_p^2 \leq 0.14$ representing a medium, and $\eta_p^2 \geq 0.14$ representing a large effect [57]. d_{Cohen} , Effect sizes for pairwise comparisons were calculated as Cohen's d , with $d=0.2$ reflecting a small, $d=0.5$ a medium and $d=0.8$ a large effect [58]. *Note.* ^aOnly the main effects are presented, as the interactions between *pattern* and *LBP presence* were not significant in the M(ANOVA) models, respectively. ^bSignificant pairwise comparisons after Bonferroni-Holm correction accounting for six comparisons, with the level of significance set at $p \leq 0.05$. ^cFor Anxiety/Depression, values were missing for 28 athletes with LBP and 15 athletes of controls, these athletes were excluded from the MANOVA and subsequent one-way ANOVAs. Therefore, means and standard deviations for the avoidance-related variables are presented only for $n=410$ athletes with LBP and $n=320$ controls.

tests demonstrated significantly more positive mood despite pain in DER, EER and AR compared to FAR, as well as more pronounced thought suppression and humor/distraction in DER and EER than in FAR and AR. Furthermore, the ANOVAs demonstrated significantly less thought suppression and more humor/distraction in athletes with LBP than in controls. No differences were found for positive mood despite pain.

Avoidance-related variables. For anxiety/depression, values were missing for 28 athletes with LBP and 15 controls, representing 5.6% of the sample; therefore, these athletes were excluded from the MANOVA and subsequent ANOVAs. The MANOVA indicated significant multivariate effects of *pattern* ($V=0.214$, $F(15,2160)=11.04$, $p < 0.001$, $\eta_p^2=0.071$) and *LBP presence* ($V=0.046$, $F(5,718)=6.87$, $p < 0.001$, $\eta_p^2=0.046$), but no significant *pattern***LBP presence* interaction ($V=0.027$, $F(15,2160)=1.31$, $p=0.186$, $\eta_p^2=0.009$). Subsequent univariate ANOVAs showed that the AEM-based patterns differed significantly in all avoidance-related variables. Post-hoc tests indicated significantly higher scores in anxiety/depression, help-/hopelessness, and catastrophizing in FAR and DER than in EER and AR. FAR further displayed significantly higher scores on both avoidance of physical and social activities than the other patterns. Furthermore, the ANOVAs revealed that athletes with LBP and controls differed significantly with respect to help-/hopelessness, avoidance of social activities, and avoidance of physical activities, with more pronounced help-/hopelessness and

less pronounced avoidance in athletes with LBP than in controls. No differences were observed regarding anxiety/depression and catastrophizing.

Depression. A significant main effect of *pattern* emerged. Post-hoc tests showed significantly higher depression scores in FAR and DER compared to EER and AR. Neither the main effect of *LBP presence* nor the *pattern***LBP presence* interaction reached significance.

Training frequency. A significant main effect of *pattern* emerged. Post-hoc tests showed significantly higher training frequency in DER compared to EER and AR. Neither the main effect of *LBP presence* nor the *pattern***LBP presence* interaction were significant.

Outcome-based validity of AEM-based patterns in athletes with LBP

The results of the ANOVAs and significant pattern differences in pain outcomes in athletes with LBP are presented in Table 3.

Pain intensity. The ANOVA revealed a significant main effect of *pattern*. Post-hoc tests indicated significantly higher pain intensity in FAR, DER and EER compared to AR, and significantly higher pain intensity in DER compared to EER.

Pain-related disability. The ANOVA indicated a significant main effect of *pattern*. Post-hoc tests indicated

Table 3: Outcome-based validity of pain response patterns based on the avoidance-endurance model in athletes suffering from low back pain, as analysed by means ($\pm$ standard deviations), univariate analyses of variance (ANOVA) and Bonferroni-Holm corrected post-hoc t-tests.

Pain outcome variable	Total sample	DER	EER	FAR	AR	Main effect pattern	Significant pairwise comparisons ^a	Effect size d_{Cohen}
Pain intensity (0–100)	35.51 (17.97)	42.46 (18.40)	35.42 (17.24)	38.68 (20.54)	28.28 (15.17)	$F(3,434)=10.99$ $p < 0.001$ $\eta_p^2=0.071$	DER>EER/FAR>AR	0.85/0.43/0.61
Pain-related disability (0–100)	12.05 (14.48)	18.58 (17.93)	9.93 (12.16)	16.95 (17.02)	8.61 (11.92)	$F(3,434)=11.81$ $p < 0.001$ $\eta_p^2=0.075$	DER>EER/AR	0.61/0.66
Training-related disability (0–10)	2.57 (2.43)	3.08 (2.77)	2.38 (2.28)	3.60 (2.76)	2.10 (2.05)	$F(3,434)=5.76$ $p=0.001$ $\eta_p^2=0.038$	FAR>EER/AR	0.54/0.61
Competition-related disability (0–10)	1.71 (2.51)	2.26 (2.85)	1.46 (2.26)	2.91 (3.15)	1.24 (2.15)	$F(3,434)=6.81$ $p < 0.001$ $\eta_p^2=0.045$	DER>EER/AR	0.41/0.66
							FAR>EER	0.52
							DER>EER/AR	0.33/0.41
							FAR>EER/AR	0.59/0.67

DER, Distress-endurance pattern; EER, Eustress-endurance pattern; FAR, Fear-avoidance pattern; AR, Adaptive pattern; F , F statistic; p : Level of statistical significance; η_p^2 , Effect sizes of group effects were calculated as partial eta squared, with $\eta_p^2 \leq 0.06$ representing a small, $\eta_p^2 \leq 0.14$ representing a medium, and $\eta_p^2 \geq 0.14$ representing a large effect [57]; d_{Cohen} , Effect sizes for pairwise comparisons were calculated as Cohen's d , with $d=0.2$ reflecting a small, $d=0.5$ a medium and $d=0.8$ a large effect [58]. *Note.* ^aSignificant pairwise comparisons after Bonferroni-Holm correction accounting for six comparisons, with the level of significance set at $p \leq 0.05$.

significantly higher disability scores in FAR and DER compared to EER and AR.

Training-related disability. The ANOVA revealed a significant main effect of *pattern*. Post-hoc tests indicated significantly higher training-related disability in FAR and DER compared to AR, and in FAR compared to EER.

Competition-related disability. The ANOVA revealed a significant main effect of *pattern*. Post-hoc tests revealed that FAR and DER displayed significantly higher disability scores than EER and AR.

Discussion

This study for the first time investigated the frequency and validity of different psychosocial pain response patterns in high-performance athletes with and without low back pain (LBP). Based on the avoidance-endurance model (AEM), three dysfunctional patterns (fear-avoidance, FAR; distress-endurance, DER; eustress-endurance, EER) were distinguished, beside an adaptive pattern (AR). EER occurred most frequently, irrespective of the presence of LBP. Among the athletes with LBP, all subgroups with a dysfunctional pattern reported significantly higher LBP intensity than AR, with FAR and DER further reporting highest disability in daily life, training, and competition. Despite highest pain and disability scores, DER also revealed the highest training frequency, indicating DER as the most problematic pattern. These results show that the dysfunctionality of FAR, DER, and EER is based on

different features of their responses to pain, emphasizing the need for individualized LBP management in athletes.

Athletes showing a eustress-endurance pattern

As expected, EER occurred most frequently in both athletic groups. This is in contrast to studies in non-athletic LBP samples that have consistently reported EER to be among the least frequent patterns [7, 12, 27] (Table 4).

In athletes, acquiring the willingness to accept pain is suggested as a way to gain success [59]. “Playing through” pain [33, 35, 36] – as an example of endurance behavior – is not only accepted, but also reinforced within the athletes’ social network [60]. Moreover, despite long-term detrimental

Table 4: Relative frequencies of patterns based on the avoidance-endurance model in samples suffering from low back pain, as reported in previous studies and the current study.

Study	Sample size	DER	EER	FAR	AR
Fehrmann et al. [27]	137 chronic LBP	34.0%	17.0%	24.0%	25.0%
Hasenbring et al. [7]	177 subacute LBP	19.2%	16.4%	9.6%	54.8%
Plaas et al. [12]	49 LBP	18.4%	12.2%	8.2%	61.2%
Titze et al. (Current study)	438 LBP (athletes)	20.1%	47.0%	9.8%	23.1%

LBP, Low back pain; DER, Distress-endurance pattern; EER, Eustress-endurance pattern; FAR, Fear-avoidance pattern; AR, Adaptive pattern.

effects [7, 15], endurance behavior seems to have particular short-term benefits. For example, it has been associated with a reduced stress reaction to experimental pain [61]. Thus, the high frequency of EER among athletes might be a consequence of operant learning processes, conceptualizing the relationship between pain and reward [62].

According to the AEM [15, 16], certain cognitive and affective pain responses can facilitate such endurance behavior, which accords well with the current findings on behavioral validity, i.e. more endurance- and less avoidance-related pain responses in athletes with an EER pattern. These athletes not only showed more positive mood despite pain than FAR and more pronounced thought suppression and distraction than FAR and AR, but also less anxiety/depression, help-/hopelessness and catastrophizing than FAR and DER, and least self-reported avoidance behavior.

Moreover, as expected, EER appeared to be dysfunctional only with respect to pain intensity, but did not differ from AR in training frequency or disability outcomes, which is also in line with studies in non-athletes with LBP [7, 12, 27]. The AEM proposes that, in EER, the observed tendencies to distract oneself from pain and maintain a positive mood can lead to low levels of perceived disability despite severe pain [15, 16]. Importantly, in this study, the majority of the athletes with LBP suffered from acute or intermittent pain, which highlights the crucial role of dysfunctional pain responses already at an early stage of pain development. Our findings therefore emphasize the need to focus more strongly on endurance-related pain responses in LBP management in athletes.

Still, the definition of *dysfunctional* endurance behavior remains a future challenge, as it may not only depend on the mode or amount of activity despite pain, but also on the type of pain, i.e. whether pain occurs as part of a sports activity or as a consequence of an illness/injury. For example, Diehl et al. [37] reported that 43.8% of German junior athletes were willing to participate in a competition despite acute joint pain under rest. These alarming results imply a careful distinction between severe clinical pain and temporary pain during training to prevent endurance behavior when it is not useful.

Athletes showing a distress-endurance pattern

In comparison to EER, DER occurred less often, even in the athletes suffering from LBP. This is in contrast to previous studies that indicated higher frequencies of DER than EER in LBP samples [7, 12, 27]. A possible explanation for the lower frequency of DER might be a selection effect, as our samples represent an extraordinarily successful

population concerning athletic achievement, possibly protecting them from depressive mood. Indeed, although mood does not seem to predict overall athletic achievement, there is some evidence for an association between successful performance and less pre-performance depression [63]. This is in line with our finding that athletes with a DER pattern also displayed higher levels of depression than EER and AR, concomitantly with more anxiety, help-/hopelessness and catastrophizing. Another reason for our results may be the mood-enhancing effects of exercise [64, 65], counteracting depressive mood.

Interestingly, athletes with a DER pattern reported more weekly training hours than EER and AR despite highest levels of pain and disability. Our results resemble the findings of a study showing highest levels of accelerometer-assessed daily-life activity despite more pronounced pain and disability in non-athletic DER patients with LBP [12]. We assume that individuals with a DER pattern may underestimate their real training behavior and suffer from supposed “low levels” of training frequency, perhaps because they may have shown signs of overactivity before the onset of LBP. Verbunt et al. [66] have discussed this hypothesis for non-athletes with LBP.

In sum, athletes with a DER pattern appear as the most problematic subgroup, not only with more pain and disability in daily-life, training and competition despite extensive training behavior, but also regarding depressive mood and help-/hopelessness.

Athletes showing a fear-avoidance pattern

FAR was found least often which corroborates findings in non-athletes with LBP [7, 12]. Given the literature on the reinforcement of endurance behavior in sports [60], it is surprising that FAR even exists among athletes. With respect to behavioral validity, athletes with a FAR pattern reported not only more anxiety/depression, help-/hopelessness and catastrophizing than EER and AR, but also most behavioral avoidance. This is in line with some evidence for FAR responses in athletes [43, 67, 68], particularly during or after injury [69–71]. However, FAR in this study reported similar training frequencies as EER and AR, which was unexpected and is in contrast to a study showing lowest levels of physical activity, constant strain postures and standing time, and highest levels of lying time in non-athletic FAR patients with LBP [12]. An explanation for this discrepancy could be that the minimum amount of training in high-performance athletes is rather standardized than self-selected, leaving few options for training reduction. Beside more pain and pain-related

disability than AR, FAR also reported highest levels of training- and competition-related disability, suggesting them to be a group that needs extra attention in pain management, e.g., by decreasing avoidance behavior while maintaining or increasing activity pacing [72].

Athletes showing an adaptive pattern

Athletes suffering from LBP with an AR pattern were of relatively low frequency in this study. With respect to behavioral validity, they revealed lowest levels of pain-related anxiety and depressive mood, lowest cognitions of help/hopelessness and catastrophizing, but moderate levels in avoidance and endurance behavior. Concerning outcome-based validity, AR displayed lowest pain intensity, and less disability in daily life, training and competitions than DER and FAR. They further seemed to maintain their training frequency despite pain, as there was no difference between athletes with and without LBP. Hence, AR might be characterized by a recently proposed mindset of resilience that should be communicated in LBP management in athletes, i.e. to experience exercise as not dangerous, to maintain load to the extent possible, and to maintain fitness, performance and resilience to further pain or injury [73].

Limitations

Several limitations of this study deserve consideration. First, as we assessed pain duration using a categorical division, we were unable to distinguish between acute, subacute and chronic LBP states [74]. However, the AEM-based patterns did not differ in pain duration. Biases in outcome variables due to unbalanced pain state frequencies among the patterns are therefore less likely. Second, while investigating differences in training frequency, we neither assessed training intensity parameters nor the amount of daily or treatment-related physical activity. It will be an important goal for future research to identify further activity-related variables associated with particular AEM-based patterns. Third, different sports disciplines may have been unequally represented among the AEM-based patterns. It thus seems necessary to re-examine the patterns separately for different disciplines. Fourth, pain outcomes were assessed retrospectively, and for some athletes, the occurrence of LBP may have deviated from the time of survey completion, raising the possibility of memory bias. Longitudinal studies are required to validate our results during more immediate experiences of

pain. Last, we cannot rule out that, in athletes with LBP, pain ratings may have been biased by other spine-related symptoms, such as upper back pain.

Conclusions

This study provides evidence for AEM-based patterns in high-performance athletes with LBP. EER seems to be highly overrepresented in this population, compared to studies in non-athletes. As endurance-related pain responses occur frequently among athletes and – at least in athletes with a DER pattern – appear to be associated with poor outcome in pain and disability, our results demonstrate the need to incorporate cognitive-behavioral interventions into LBP management programs. They further indicate that psychological training concepts [75, 76] may be extended by targeting an optimal balance between performance and pain regulation.

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