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**THE ROLE OF PSYCHOLOGICAL RECOVERY IN  
BACK PAIN PREVENTION AND REHABILITATION**

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## Abstract

Psychosocial influences have materialized as important facets in the context of back pain prevention and rehabilitation. Despite their contribution to the onset and chronification of back pain, the magnitude of their effectiveness is limited due to a lack of tailored and individualized interventions. Recovery as a restorative psychological process has emerged as a protective factor against numerous health issues and stress and was assumed to play a role for back pain as well. Hence, the aim of the dissertation consisted in the investigation of associations between recovery and back pain from different perspectives via three different studies.

The first empirical study reported in manuscript 4.1 served as the foundation to examine the relationship between recovery-stress patterns and back pain (i.e., *Pain Intensity*, *Disability*). Individuals with negative recovery-stress patterns (i.e., low recovery, high stress) showed significantly more *Pain Intensity* and *Disability* than those individuals with a positive ratio between *Recovery* and *Stress* (i.e., high recovery, low stress). The outcomes of manuscript 4.1 implied that *Recovery* and *Stress* should be considered and adapted to positively influence *Pain Intensity* and *Disability* in terms of a reduction.

Manuscript 4.2 describes the evaluation of recovery interventions for back pain prevention in an out-patient preventive treatment. Over a time span of three months, the intervention group received a multimodal prevention program which was complemented by interventions to promote recovery. In comparison to the control group (no treatment), all outcome parameters ameliorated in the intervention group. *Stress*, *Pain Intensity* and *Disability* reduced while *Recovery* enhanced. These results reflect the effectiveness of the prevention program in combination with the recovery tools. It can be stated that recovery may serve as a valuable addition in multimodal prevention programs to foster the reduction of back pain.

A similar approach was evaluated in the third and final study (manuscript 4.3). Recovery interventions were implemented in an out-patient rehabilitation program for individuals on sick leave due to their chronic back pain. Again, the intervention group was evaluated against a control group which received the identical intervention as the intervention group without the recovery add-ons. The acute intervention effects after two weeks did not show statistically higher values for the intervention group. *Stress*, *Pain Intensity*, and *Disability* decreased equally, while *Recovery* displayed a comparable improvement in both groups. It can be

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assumed that changes in recovery-related behavior might require more than two weeks to manifest and may therefore affect the long-term improvement of back pain.

Recovery as a process of unwinding and resource restoration appears to be linked to back pain and should be considered as a promising approach in back pain prevention and rehabilitation.

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## Zusammenfassung

Für die Prävention und Rehabilitation von Rückenschmerz haben sich psychosoziale Einflüsse als bedeutsame Faktoren etabliert. Obwohl diese zur Entstehung und Chronifizierung von Rückenschmerz beitragen, schränkt die mangelnde Individualisierbarkeit vieler psychosozialer Interventionen deren Effektivität ein. Einen neuen Ansatz in der Rückenschmerztherapie könnte die Förderung von Erholung darstellen. Erholung als ressourcenorientierter psychischer Prozess konnte bereits mit verschiedenen Krankheitsbildern assoziiert werden und hat sich zudem als effektiv zur Kompensation von psychischer Beanspruchung erwiesen. Das Ziel dieser Dissertation bestand daher in der Untersuchung von Erholungsprozessen im Kontext von Rückenschmerz mit Hilfe dreier empirischer Studien.

Die erste Studie (Manuskript 4.1) fungierte als Grundlagenuntersuchung zur Analyse von Erholungs-Beanspruchungsmustern und deren Beziehung zu rückenbezogener Schmerzintensität und Beeinträchtigung. Eine ungünstige Konstellation aus zu wenig Erholung und zu viel Beanspruchung resultierte in einer erhöhten Schmerzintensität und Beeinträchtigung im Vergleich zu einem günstigen Verhältnis aus viel Erholung und wenig Beanspruchung. Diese Ergebnisse implizieren, dass die Stellschrauben Erholung und Beanspruchung bearbeitet werden sollten, um eine Reduktion von Schmerzintensität und Beeinträchtigung durch Rückenschmerz zu fördern.

Die darauffolgende Studie (Manuskript 4.2) beschreibt die Untersuchung von Erholungsinterventionen in einem ambulanten Rückenschmerzpräventionsprogramm. Über einen Zeitraum von drei Monaten erhielt die Interventionsgruppe Bausteine zur Erholungsförderung, welche in das reguläre multimodale Behandlungssetting eingebettet wurden. Gegenüber einer Kontrollgruppe (ohne Behandlung) verbesserten sich alle Zielparameter in der Interventionsgruppe. Die psychische Beanspruchung, Schmerzintensität und Beeinträchtigung nahmen ab, während sich die wahrgenommene Erholung verbesserte. Diese Befunde weisen auf die Wirksamkeit der Erholungsbausteine im präventiven Kontext hin. Erholung kann basierend auf diesen Analysen als sinnvolle Ergänzung zur multimodalen Prävention von Rückenschmerz bewertet werden.

In Anknüpfung an diese Befunde in der präventiven Behandlung wurde ein ähnlicher Ansatz in der Rehabilitation von chronischen Rückenschmerzen in der letzten Studie (Manuskript

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4.3) evaluiert. Wieder erfolgte ein Vergleich zwischen einer Interventions- und Kontrollgruppe. Die beiden Gruppen erhielten die identischen multimodalen Inhalte im Rehabilitationsprogramm, wobei die Inhalte der Interventionsgruppe um die Vermittlung von Erholungseinheiten ergänzt wurden. Die Auswertung der akuten Entwicklungen nach den ersten zwei Wochen des Programms zeigte keine statistisch signifikanteren Effekte für die Interventionsgruppe gegenüber der Kontrollgruppe hinsichtlich der zugrundeliegenden Zielparameter. Die psychische Beanspruchung, Schmerzintensität und Beeinträchtigung sanken in ähnlichem Ausmaß in den beiden Gruppen, während die Erholung einen vergleichbaren Anstieg verzeichnete. Möglicherweise manifestiert sich der zusätzliche Effekt der Erholungsinterventionen erst auf langfristige Sicht, wenn die Inhalte der Erholungsbausteine internalisiert und in dauerhaftes Verhalten umgesetzt wurden.

Erholung im Sinne der Wiederherstellung der eigenen Ressourcen scheint mit dem Phänomen Rückenschmerz in einer Beziehung zu stehen. Die Befunde dieser Doktorarbeit deuten darauf hin, dass Erholungsbausteine einen vielversprechenden Ansatz in der Rückenschmerzprävention und –rehabilitation charakterisieren und als Grundlage für weitere Forschung in diesem Feld dienen können.

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## 1 Introduction

Back pain (BP) can be described as a condition with many faces. Definitions, etiological models, and potential treatments display a great variety and differ depending on the target population (e.g., employees, athletes) or duration of BP (Deyo et al., 2014; Gatchel, 2015; Gore, Sadosky, Stacey, Tai, & Leslie, 2012). BP characterizes a pain which is perceived in different areas of the spine (i.e., cervical, thoracic, lumbar) and affects muscular, bony, or ligament structures. In the context of BP examinations, almost the entire body of research focuses on low BP, which van Tulder et al. (2006) define “as pain and discomfort, localised below the costal margin and above the inferior gluteal folds, with or without leg pain” (p. 171). BP is generally considered as a symptom but may establish as a discrete clinical disease in case a chronic (> three months) course of BP cannot be prevented (Deyo et al., 2014). Due to the multifactorial influences contributing to BP development, it is often labelled as a nonspecific phenomenon that lacks a clear pathophysiological origin and etiology (Balagué, Mannion, Pellise, & Cedraschi, 2012).

Demographic, physical, biological, and psychosocial factors interact and contribute to the complex character of the burden. This broad understanding of BP developed over the past thirty years and signified a shift from a pure biomedical perspective towards a biopsychosocial understanding of the condition (Pincus et al., 2013). To provide a vivid example of the biopsychosocial underpinnings of BP, a case study of a 42-year-old female who has been suffering from chronic BP for two years will be presented. The case is fictional but based on the thoughts and symptoms of a real person affected:

*Back pain has established as a constant companion at work and in my everyday life. The pain intensity is changing depending on my mood and stress intensity and can be unbearable at times. Especially at work I cannot focus and have to take frequent breaks to alleviate the pain. My productivity has dropped considerably and sometimes I need to take a few days off because my back pain is simply overwhelming. In the beginning, I did not even notice that the pain was present and I was denying the fact that it affected my functioning. I think it was a combination of bad body posture, social conflicts, and increased stress levels due to a new position at my job that caused the back pain in the first place. I used to go swimming twice a week but with the new challenges and increased work load at the job, I could not find the energy to visit the swimming pool after work. These factors seemingly interacted and deteriorated my condition. The back pain got worse and consequently my mood soured and*

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*my performance at work and at home declined. My back muscles in the lumbar area were under constant pressure without any relief. Intruding thoughts such as “Every time I lean forward, my back explodes” or “I cannot fight the pain anymore” accompanied all my actions and affected my behavior negatively. I withdrew from social activities and focused on pain reduction by avoiding critical pain-related situations.*

*After a few months, I was pursuing strategies to cope with the pain and reduce its influence on my daily life. I visited a doctor who prescribed me pain medication and informed me about certain exercises to stabilize my core. The medication led to a short-term improvement, but did not translate into a long-term reduction of my burden. I tried a few of the exercises initially but was not able to practice them on a regular basis. After talking to fellow sufferers, I realized that my problem was not exclusively related to physical factors but also to psychological processes and influences. Still, I was not prepared to seek advice with a psychotherapist or enroll in a time-consuming multimodal rehabilitation program which would have meant a significant time off work. With the help of my physiotherapist, I identified stress as the strongest source to intensify my back pain. Every time I felt exhausted and stressed during and after work, I already anticipated my mind and body to punish me through a tensed and aching back. For this reason, I tried to modify my perception of stress and at the same time, reserve time slots to focus on recovery in terms of unwinding and resourceful activities. I practiced relaxation techniques and started to swim again, since I considered swimming as a strategy to detach and as a source of strength. Implementing these recovery strategies into my daily life relieved my back pain considerably, gave me new motivation to fight my back pain and increased my self-efficacy. I noticed that I was not helplessly exposed to my back pain since I developed efficient strategies to deal with the pain. Recovery was one adjustment I was capable of which in turn changed my ability to deal with my pain. The recovery activities supported me to find the energy to focus on the physical and social factors which also promoted the chronification of my back pain.*

This case report includes a number of different factors which may contribute to both the onset and chronification of BP. Unfortunately, this fictional history of suffering is not an isolated case but is representative for a multitude of affected individuals with similar stories. The negative consequences of BP and chronic BP in particular not only affect individual functioning but are also accompanied by substantial economic, social, and work-related repercussions (Hoy, Brooks, Blyth, & Buchbinder, 2010; Wynne-Jones et al., 2014). Since BP affects up to 80 % of the population at a certain point in their life, the burden represents the

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most prevalent musculoskeletal disorder (Hoy et al., 2012). A plethora of studies classify BP as one of the leading causes for disability worldwide and as a significant financial cost factor due to sick leave days, work absenteeism, or even permanent inability to work (Gore et al., 2012; Murray et al., 2012). Health care systems in various countries are confronted with the problem of omnipresent BP and invest a considerable amount of money into prevention and rehabilitation programs. Despite these efforts to stem BP development and alleviate the problems of chronic BP patients, the burden continues to be on the increase (Manchikanti, Singh, Falco, Benyamin, & Hirsch, 2014; Taylor, Goode, George, & Cook, 2014). Considering the life style changes (e.g., sedentary occupations, digitalization) of the past few years in combination with the multifactorial nature of BP, it does not seem surprising that effective approaches to comprehensively deal with BP remain difficult to apply and design. In light of this state-of-the-art prevention and rehabilitation regarding BP, the central aim of this dissertation consists in the evaluation of the aspect of psychological recovery as an individualized and resource oriented approach to face BP.

## 2 Theoretical background

### 2.1 Biopsychosocial underpinnings of back pain

Before effective strategies for BP prevention and rehabilitation can be administered, knowledge about the etiological foundations of the condition needs to be gathered and transferred into practice. Research in the field of BP etiology identified a myriad of factors affecting the first manifestation and chronification of BP (Müller-Schwefe et al., 2017; Nicholas, Linton, Watson, & Main, 2011; Taylor et al., 2014). The case study demonstrated a selection of biological (e.g., body position, unfavorable movement patterns) and psychosocial (e.g., social withdrawal, dysfunctional thoughts) influences that interacted and initiated a vicious circle which ultimately led to a chronification of BP. Since the list of potential risk factors associated with BP appears to be endless, only a selection of the most investigated and prevalent ones will be presented to give an impression of the existing fundamentals of BP.

#### 2.1.1 Sociodemographic factors and back pain

The combination and statistical analysis of sociological and demographical (i.e., characteristics related to the population) factors describe the term *sociodemographic* (sociodemographic, 2018). These correlates of sociological and demographical variables received significant attention in studies examining epidemiological underpinnings of BP and

have also been pronounced as influential factors in the case study. Exemplary sociodemographic factors encompass variables such as age, gender, marital status, or education level. These facets are frequently assessed in BP studies since they impact the onset and course of the condition (Chou, Shih, Lin, Chen, & Liao, 2013; Grotle et al., 2005; Hoy et al., 2010).

Regarding the sociodemographic factor age, studies indicate an incidence peak in the third decade with a steady increase of prevalence until the age 60-65 (Hoy et al., 2010; Waterman, Belmont, & Schoenfeld, 2012). These findings can be attributed to processes of wear and tear across the life span. Accumulating loads with increasing age together with a shift towards a dysfunctional and unhealthy sedentary life style affect the vertebrae and related structures negatively. Anatomical changes characterized through increased stiffness and loss of flexibility in the intervertebral discs may contribute to an augmentation of BP with growing age (Wong, Karppinen, & Samartzis, 2017). For gender, data obtained from numerous epidemiological studies confirm that BP seems to be more common in women than in men (Chou et al., 2013; Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley, 2009). This ‘gender pain bias’ is surprising since women in general report a healthier life style, less overweight, and less exposition to chronic stress (Schneider, Randoll, & Buchner, 2006). Explanations why these gender discrepancies in pain prevalence exist were synthesized by Wáng, Wáng, and Káplár (2016). Physiological differences could be identified as strong contributor to the higher BP prevalence in women. Female hormone fluctuation seems to favor the development of BP and is more accentuated after the menopause.

Another influential aspect in the context of BP is the marital status of a person (Ganesan, Acharya, Chauhan, & Acharya, 2017). Apparently, being in a relationship can serve as a protective factor against BP. This might be explained by the social support provided by a spouse or unmarried partner accompanied by a stronger and more extensive social network (Shaw, Campbell, Nelson, Main, & Linton, 2013). Schmidt et al. (2007) investigated the relationship between sociodemographic characteristics and disabling BP in a large multiregional sample in Germany. The authors described disabling BP as a social disadvantage significantly associated with a low education level. Similar findings are reported in other countries like France (Leclerc et al., 2009), United States (Shmagel, Foley, & Ibrahim, 2016), or Iran (Noormohammadpour et al., 2017). These findings suggest that a lower education level is globally connected with poorer BP status and less favorable outcomes.

This passage only presented a very small excerpt of the existing literature but already elaborated on a number of different sociodemographic influences. The potpourri of sociodemographic factors and their complex interrelatedness therefore needs to be taken into account when analyzing potential risk factors and planning prevention and rehabilitation programs.

### ***2.1.2 Biological factors and back pain***

Biological factors include a broad range of sub-facets such as biomechanical or physiological aspects in the context of BP. They can be summarized as those influences that are directly related to physical conditions of the organism. The fictional person in the case study listed bad body posture as one crucial aspect to impact her BP. The consequence of such awkward body postures and repetitive heavy lifting are high loadings on the spine which are assumed to be prominent biomechanical risk factors for BP both in the working population (Coenen, Kingma, Boot, Bongers, & van Dieen, 2014; da Costa & Vieira, 2009) and among athletes (Campbell, Straker, O'Sullivan, Elliott, & Reid, 2013; Spörri, Kröll, Haid, Fasel, & Müller, 2015). These dysfunctional movements may consist of compressive loads affecting the end-plates of the vertebrae or full-range flexions or extensions affecting the muscular and ligament structures (O'Sullivan, 2005). Various tissue injuries may be the result which in turn may denote the starting point of long-term BP induced disability. However, the relationship between the amount of loading and increased risk for back injuries cannot be portrayed in a simplistic manner. Rather, the right amount of loading, depending on the current situation of the individual, needs to be evaluated. For athletes, it may rather be recommended to reduce the excessive loadings placed on the back, while many individuals in sedentary occupations would benefit from a certain dosage of loading to stabilize the muscular structures and increase the flexibility especially in the lumbar spine (McGill, 2016). The combination of excessive loading (e.g., duration, repetitions) and unfavorable body positions (e.g., hyperextension, bending) may overwork the spinal structures and cause microtrauma in the spinal area (McGill, 2016). Limited activity and resulting detrimental psychological processes (e.g., depressive mood) may then promote a chronification of BP. Despite a considerable number of studies examining the role of physical factors for BP development, clear associations between physical risk factors and BP remain ambiguous and scarce (Coenen et al., 2014).

Physical activity is an additional biological factor which is continuously discussed in light of BP (Sitthipornvorakul, Janwantanakul, Purepong, Pensri, & van der Beek, 2011). While physical activity is recommended as a central element for BP prevention and rehabilitation,

the right amount of exercise has not been determined so far (Heneweer, Staes, Aufdemkampe, van Rijn, & Vanhees, 2011; Lin et al., 2011). However, both inactivity as well as excessive amounts of rigorous physical activity (which is the case for elite athletes) seem to promote BP development (Lin et al., 2011; Trompeter, Fett, & Platen, 2017). Overall, mixed evidence regarding the strength of the biological factors' influence on BP can be reported but their importance in the context of BP can only be assumed.

### ***2.1.3 Psychosocial factors and back pain***

While physical determinants affect BP development and chronification, research attributes stronger evidence to psychosocial factors (Vargas-Prada & Coggon, 2015). *Psychosocial* factors describe aspects regarding the interaction of psychological (i.e., related to the mind) and social (i.e., related to interaction with other individuals) influences in light of BP (psychosocial, 2018). The list of psychosocial factors linked to BP development and chronification retrieved in various settings (e.g., occupational environments, primary care) is extensive. Due to the heterogeneity of definitions, measurement approaches, and characteristics of the study design, the identification of universal psychosocial risk factors cannot be yielded. Nevertheless, a few factors are documented as being prominent in various settings of BP research. These are distress, negative mood (e.g., anxiety, depression), and adverse coping strategies such as avoidance (Pincus et al., 2013; Taylor et al., 2014; Vargas-Prada & Coggon, 2015). In order to achieve a deeper understanding of the multifacetedness of psychosocial influences on BP, evidence obtained from systematic reviews with different foci should be presented. Pincus, Burton, Vogel, and Field (2002) conducted an informative and thorough systematic review of psychosocial risk factors associated with BP related disability and chronicity. Depressive mood and psychological distress emerged as the two central psychosocial aspects which could be supported by the synthesized research. Other psychosocial influences potentially impacting a transition from acute to chronic BP encompassed somatization and dysfunctional coping strategies (e.g., catastrophizing). These central findings could be confirmed in other systematic reviews published since 2002.

Taylor et al. (2014) focused on primary prevention of BP in both occupational and community settings and elaborated on physical and psychosocial factors. Regardless of the BP definition, the incidence of BP was similar in occupational and community environments, while the nature of psychosocial factors varied depending on the setting. In occupational settings, mental and interpersonal stress as well as interpersonal conflicts with colleagues were linked to the incidence of BP. Within community settings, factors such as depressive mood, low

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social status, and job dissatisfaction showed a relationship with the onset of BP. Hauke, Flintrop, Brun, and Rugulies (2011) specifically focused on the work setting as critical environment for BP genesis. The researchers collected prospective evidence on the influence of work-related psychosocial factors on the onset of pain in various musculoskeletal regions. Low social support and high job demands were examined in the majority of the prospective studies and resulted as risk factors for BP onset. Low job control, skill discretion, and job satisfaction together with high job strain added to the interplay of psychosocial factors associated with BP onset extracted in this systematic review. Psychological distress was only included in nine analyzed studies and therefore did not provide sufficient evidence for the specific region of the back. While Taylor et al. (2014) and Hauke et al. (2011) summarized data regarding psychosocial risk factors for BP onset, information about psychosocial factors contributing to a chronification of BP is equally important. For the very same reason, Laisné, Lecomte, and Corbière (2012) conducted a systematic review to scrutinize the impact of biopsychosocial factors for musculoskeletal disorders. On the psychological level, cognitive processing of pain (i.e., recovery expectations), somatization, and coping strategies provided robust evidence to serve as risk factors for pain chronification. Finally, Nicholas et al. (2011) examined psychological risk factors ('yellow flags') and their value for the early identification of BP and their implication for a chronic course of BP. Psychological risk factors involved the superordinate categories of beliefs, appraisals, and judgements, emotional responses (i.e., mental distress), and pain behavior (including coping strategies). Regarding the evidence of these aspects, it can be stated that consistent patterns of catastrophizing, depressive mood, and pronounced fear-avoidance beliefs more likely foster the development of persistent pain issues. It can be assumed that the interaction of these psychological determinants initiates a vicious circle which produces stress and influences physiological processes of pain development (Truchon, Côté, Fillion, Arsenault, & Dionne, 2008).

Based on the presented research synopsis on psychosocial factors, a number of characteristics appear to have implications for BP onset and chronicity across different settings. This knowledge about etiological underpinnings transfers to multimodal concepts of BP prevention and rehabilitation where psychosocial factors established as central and indispensable elements. Since the superiority of psychosocial facets for the explanation of BP has been emphasized in research (Pincus et al., 2013; Pincus & McCracken, 2013), the impact and nature of psychosocial factors in prevention and rehabilitation approaches will be described in detail.

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## 2.2 Back pain prevention: A focus on psychosocial elements

Preventive approaches to deal with diseases or unfavorable health conditions can be divided into primary, secondary, and tertiary prevention according to the classification proposed by Caplan (1964). Primary prevention aims to create conditions that reduce the risk of developing a certain disease or burden. Secondary prevention intends to diminish the impact of an existing disease or injury through adequate interventions. Tertiary prevention corresponds to the more common term of rehabilitation and focuses on the alleviation of the consequences of a chronic disease. Studies to describe treatment approaches for BP with a focus on rehabilitation by far outnumber those trials which provide genuinely preventive (i.e., primary and secondary) evidence for the burden (Foster et al., 2018). Despite this imbalance, designing and implementing prevention programs remains a crucial element within the health care system. These preventive approaches are regarded as cost-effective ways to manage BP and most importantly, prevent detrimental long-term consequences of BP such as sick leave or reduced quality of life (Steffens et al., 2016). During the past decades, a shift regarding the conceptualization of preventive programs occurred. The integration of behavioral and psychological strategies to effectively reduce the risk for chronic BP gained significant attention while previously applied strategies such as pharmacological and surgical treatments faded into the background (Foster et al., 2018). The character of prevention programs changed towards multimodal concepts which account for the multifactorial (i.e., biopsychosocial) nature of BP.

The majority of multimodal preventive studies examine the effects of secondary prevention with the primary goal of targeting mechanisms to reduce the negative outcomes of BP which may be unemployment or long-term disability (Burton et al., 2005). As illustrated earlier, this might originate from the fact that potential risk factors and hazardous influences for BP onset remain challenging to assess and only provide limited evidence. This problem was already reported in a review article of the *Working Group on European Guidelines for Prevention in Low Back Pain* (Burton et al., 2005) and continues to be prevalent up to the present moment (Foster et al., 2018). Nevertheless, the multimodal prevention programs that can be identified in the literature share the communality of emphasizing the role of psychosocial aspects as central elements. The included evidence-based psychosocial aspects display a considerable diversity and range from cognitive behavioral strategies to patient education and stress management techniques. Cognitive behavioral interventions are based on knowledge derived from clinical contexts and concentrate on skills that promote self-initiation in patients to take

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control of their BP. Techniques such as visualization and cognitive restructuring exemplify tools to deal with BP from a cognitive behavioral perspective (Steffens et al., 2016; Weiner & Nordin, 2010). Stress management tools are sometimes subsumed among cognitive behavioral strategies but should be distinguished from them since they encompass specific techniques and target other psychological processes. Managing stress may be achieved through the systematic use of relaxation techniques (e.g., breathing relaxation, yoga) or the promotion of individual recovery activities (e.g., walking the dog) in terms of resource restoration (Foster et al., 2018). It can be stated that a general lack of multimodal prevention approaches is prevalent which results in scarce evidence regarding psychosocial aspects. This might be a consequence of the complex interactions between biopsychosocial factors and the heterogeneity of findings on their impact. Ways to improve the current situation in the field of psychosocial facets for BP prevention are proposed by research and focus on individualized approaches. Specific target groups (e.g., low income populations) should be treated with specific interventions and individualized psychosocial modules (Childs, Wu, Teyhen, Robinson, & George, 2014; Pincus & McCracken, 2013).

### **2.3 Back pain rehabilitation: A focus on psychosocial elements**

Multimodal programs aiming at the effective rehabilitation of chronic (> 12 weeks) BP include biological (e.g., physiotherapy, exercise), psychological (e.g., relaxation, cognitive behavioral techniques), and social components to account for the multifactorial nature of the burden (Gatchel, McGeary, McGeary, & Lippe, 2014; Kamper et al., 2015). The status quo of multimodal, biopsychosocial rehabilitation for chronic BP was summarized in a recent and extensive systematic review by researchers associated with the renowned Cochrane Collaboration (Kamper et al., 2015). The analyzed multimodal programs revealed a higher and more sustained effectiveness in the long-term for pain and disability reduction compared to unimodal physical treatments or usual care. Usual care encompassed treatment provided by the respective health care provider (e.g., general practitioner) and varied across the included studies. For work-related outcomes (e.g., return to work), biopsychosocial rehabilitation approaches were associated with better effects than physical treatment, while no superior effects were identified when measured against usual care. On the downside, multimodal rehabilitation programs produce significant financial costs, are time consuming and require considerable resources (e.g., involved staff, materials) which need to be weighed against the beneficial aspects for the patients via cost effectiveness examinations. Kamper et al. (2015) further suggest distilling the impact of specific components of the multimodal programs (e.g.,

psychological interventions) in order to refine the multimodal programs and enable a more patient specific approach within the programs.

The psychological perspective of multimodal BP rehabilitation was considered in a review article administered by Morfeld et al. (2010). Six concepts were compared and showed similarities in terms of their biopsychosocial orientation and their central aim of promoting vocational rehabilitation. On a psychological level, tools for pain, stress, and resource management as well as cognitive behavioral sessions were implemented within the programs. The majority of the rehabilitation concepts focused on an in-patient context and demonstrated a high level of standardization (i.e., manuals) of the therapeutic elements. While all programs were characterized by an integration of biological and psychological components via respective experts (e.g., physiotherapists, psychologists), the effectiveness of the different programs could not be compared due to a considerable heterogeneity in outcome parameters and assessment instruments. This significant drawback impedes a final conclusion on the quantitative impact of the different elements of the rehabilitation curricula. Morfeld et al. (2010) conclude that multimodal programs should entail a certain degree of freedom to adapt modules to the specific needs of the target population.

A specific examination of the effectiveness of psychological interventions in chronic BP rehabilitation was conducted by Reese and Mittag (2013). The authors analyzed systematic reviews and guidelines reporting about psychological elements. Low- to moderate-quality evidence was identified for three categories of psychological interventions, namely fear avoidance training, behavioral therapy, and relaxation therapy. Stress management was recommended in many guidelines but could not be corroborated through scientific evidence. Reese and Mittag (2013) highlighted the need to obtain further high-quality research which should be generated with interventional study designs including a control group. Tailored and individualized interventions were advocated which are adjustable to the specific requirements of subgroups or individuals (Reese & Mittag, 2013). A similar approach was addressed by Roch and Hampel (2016) who focused on psychological characteristics in BP rehabilitation in Germany. Twelve articles published between the years 2010 and 2015 were included into the review which analyzed inpatient, semi-inpatient, and out-patient rehabilitation as well as aftercare settings. This heterogeneity of the studies was also reflected with regard to the implemented psychological interventions (e.g., cognitive behavioral strategies, biofeedback) and their effectiveness. For those studies that included a control group, the additional psychological elements did not facilitate an add-on effect for pain and disability. Roch and

Hampel (2016) draw a conclusion analogous to other reviews in the field. They indicated that the specific effect and influence of the different biopsychosocial components remained unclear. Furthermore, the individualization of interventions according to patients' needs should be promoted which represents a complex but central and important issue that requires further investigation.

Eccleston, Morley, and Williams (2013) emphasized that the evidence regarding the effectiveness of psychological interventions in chronic BP rehabilitation continues to be inconclusive. The majority of psychological components entail cognitive behavioral, fear avoidance, and partly stress management elements but even these categories are defined inconsistently across studies. In addition, all presented reviews infer that research with regard to multimodal programs should aim to dissect the effect of each of the multimodal components (e.g., biological, psychological) and develop individualized and tailored psychological and social interventions (Kamper et al., 2015; Reese & Mittag, 2013). These specific interventions may be derived from established approaches (e.g., cognitive behavioral techniques) or may even administer new and combined approaches to design individually tailored interventions.

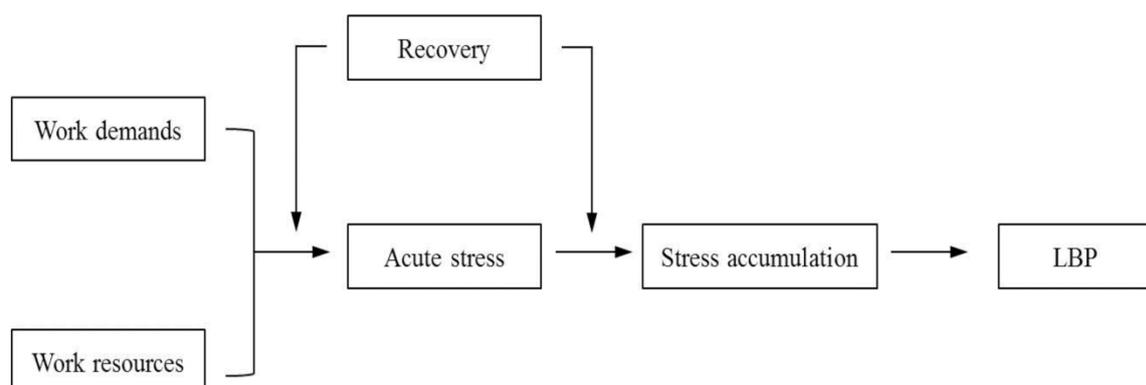
#### **2.4 Recovery – a missing piece to bring relief**

Psychosocial elements within multimodal rehabilitation programs for BP mainly encompass behavioral and fear avoidance aspects. Stress management and relaxation therapy represent other psychosocial approaches that implicate effectiveness but lack the scientific data to support their beneficial impact (Pincus & McCracken, 2013). Since psychological stress emerged as a prominent risk factor for both acute and chronic BP as well as for other health complaints (e.g., injuries), the integration of interventions that are dealing with stress should be promoted and scientifically evaluated. While a heterogeneous understanding of stress is prevalent in research, the stress construct in the context of this dissertation describes an individual's subjective perceptions and consequences resulting from external and internal challenges (Cooper, 2000). Kellmann (2002) suggested that stress coping in the context of health issues should not be contemplated as a unidimensional construct in terms of exclusively focusing on stress reduction. The anecdotal evidence presented in the case study illustrates a potential beneficial pathway for BP alleviation through recovery enhancement. This aspect connects to research in health sciences initiated a shift from disease orientated models towards more comprehensive models (e.g., salutogenetic-model) which emphasize the impact and importance of protective factors such as recovery in relation to health issues

(Antonovsky, 1996; Truchon et al., 2008). Since the accumulation of stress cannot be stopped and eluded most of the times, individuals need to concentrate on specific individual recovery strategies as personal resources to maintain a balanced health status.

The concept of recovery as a health promoting concept should therefore be taken into account in BP prevention and rehabilitation since recovery and stress are considered as intertwined and interdependent theoretical constructs (Kellmann et al., 2018). Kallus (2016) defines recovery as “an inter- and intraindividual multilevel (e.g., psychological, physiological, social) process in time for the re-establishment of personal resources and their full functional capacity” (p. 42).

Associations with recovery experiences (e.g., detachment) and health status were established in a number of studies (Aronsson, Astvik, & Gustafsson, 2013; Sonnentag & Fritz, 2015; Sonnentag, Kuttler, & Fritz, 2010). For example, Aronsson et al. (2013) conducted a cluster analysis to categorize participants based on their recovery status (‘not recovered’–‘moderately recovered’–‘recovered’). The recovery status was then used to assess the Relative Risk for work absenteeism and health conditions (e.g., BP, headache). Individuals with a detrimental recovery pattern (i.e., ‘not recovered’) showed a significantly higher Relative Risk to suffer from health complaints. This knowledge about general relationships between recovery and health was transferred into a theoretical model illustrating the role of recovery in the context of BP and the working environment (Mierswa & Kellmann, 2015). The model affirms that recovery potentially influences the process of BP development in two different ways (Figure 1).



*Figure 1.* Theoretical illustration of the preventive and restorative influence of recovery for back pain in the working environment. Adapted from “The influences of recovery on low back pain development: A theoretical model,” by T. Mierswa and M. Kellmann, 2015, *International Journal of Occupational Medicine and Environmental Health*, 28, p. 258.

First, stress reactions as a consequence of work strains can be buffered by adequate recovery. Second, recovery can serve as a valuable source to physically and psychologically restore exhausted individuals and help them to cope with BP. Mierswa and Kellmann (2015) stated that an imbalance of insufficient recovery and excessive stress may increase the probability to develop BP and continuously suffer from the burden. The model provided a starting point for research which should aim to corroborate the notional assumptions and associations. The current evidence indicates that recovery is connected to the development of BP in the general population (Mierswa & Kellmann, 2015, 2017) and is associated with a chronic course of BP among athletes (Heidari et al., 2016). Over a six month span, four different recovery-stress groups were examined with regard to their Relative Risk for developing BP in a sample of administrative employees (Mierswa & Kellmann, 2017). The group with the highest stress and lowest recovery scores was associated with higher Relative Risk for BP occurrence over time. While BP occurrence could be linked to recovery and stress for the first time, the study did not provide information on the quality of BP in terms of pain intensity and associated disability (Mierswa & Kellmann, 2017). However, this aspect is essential to examine in order to warrant prevention and rehabilitation programs for BP that entail specific recovery elements.

### **3 Aim and research questions of the dissertation**

As BP represents an omnipresent, growing, and costly health-related burden in the population, the development and validation of effective approaches to deal with BP remains a central aim in research. The existing research on recovery demonstrates the importance of recovery for several aspects of individual health (e.g., headache, musculoskeletal complaints) in various contexts as well as its significance for BP development (Aronsson et al., 2013; Mierswa & Kellmann, 2017; Sonnentag et al., 2010). The association between the quality of BP (i.e., intensity, disability) and values of recovery and stress remains an issue that needs to be investigated and transferred into practical settings. It can be assumed that the enhancement of recovery may delineate an innovative and individualized approach in prevention and rehabilitation settings through the combination of elements of stress management and relaxation. For this purpose, a number of recovery tools were developed and two of those were included in both intervention studies (4.2, 4.3). First, a reflective recovery diary was implemented aiming at the sensitization of the participants for their recovery activities as resources. The first two pages of the reflective recovery diary are demonstrated in Figure 2.

**Reflective recovery diary**

Participant identification code (e.g., PeLa08):

Your participant identification code consists of:  
 First two letters of your father's first name (e.g., Peter = Pe)  
 First two letters of your mother's first name (e.g., Laura = La)  
 Your day of birth (e.g., 05.01.85 = 08)

The reflective recovery diary serves as a tool to monitor the own recovery experiences. It will support you in raising your awareness for your personal recovery strategies and it will strengthen your resources to deal with stress. Please use the diary for a time frame of at least **one week**. You should reserve about **5-10 minutes** every evening to recapitulate and note down your recovery experiences for the day.

**How to use the reflective recovery diary correctly:**

1. Insert the current **date** and **time** in the upper left corner.
2. Go over to indicate your **back pain intensity** and **disability** on the scale in the upper right corner.
3. In the first cell of the table, enter your **sleep duration**. Please rate your sleep quality with regard to **restfulness** (from 0 = „not restful at all“ to 10 = „perfectly restful“).
4. Additional **recovery-related activities** should be listed in the column „Today's recovery-related activities“. Please write down all activities associated with recovery. The duration of those activities is unimportant. Possible activities may encompass power napping, physical activity (walking, running), reading, watching TV, applying relaxation techniques, social activities, etc.
5. Please rate these activities with regard to their **restorative value** in the column „Rating of restfulness“.
6. **Further information** about the recovery-related activities can be provided in the column „Comments“. For example, you may think about questions such as: What helped me to recover? Which factors disturbed my recovery process? Did obstacles occur that prevented me from recovering? How satisfied am I with the recovery-related activity?

**Important advice:**

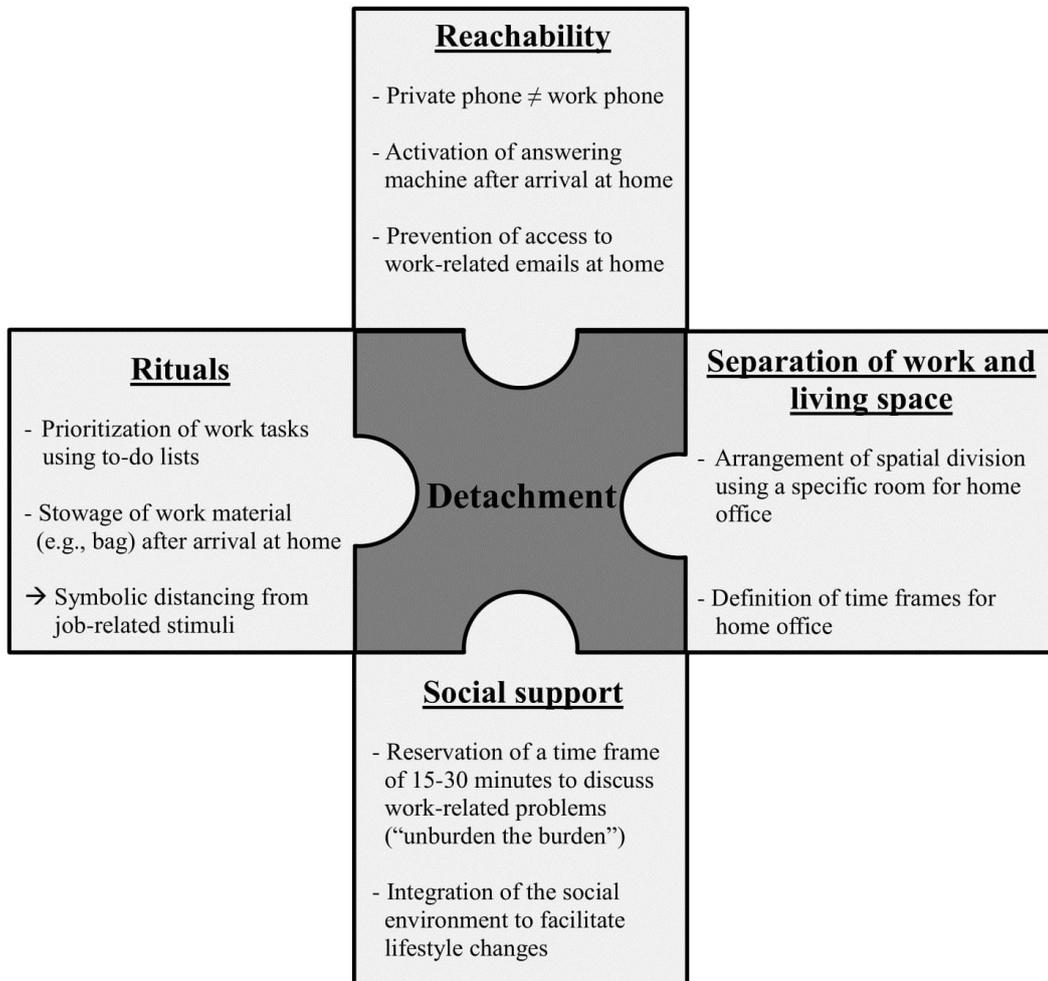
- Take some time to think about your recovery-related activities before completing the diary.
- In case you forgot to work on the diary, please make up for it on the next day.
- There is no right or wrong for recovery-related activities – it is about your subjective perception of activities.

Example of a reflective recovery diary		
Date: <u>2017/07/11</u>	Back pain intensity:	0 ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- 7 ---- 8 ---- 9 ---- 10 No Pain as bad as could be pain
Time: <u>10:20 pm</u>	Disability:	0 ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- 7 ---- 8 ---- 9 ---- 10 No Unable interference to carry on any activities
Today's recovery-related activities:	Rating of restfulness <i>From 0 „not restful at all“ to 10 „perfectly restful“</i>	Comments:
I slept <u>7.5</u> hours last night.	3	I woke up a couple of times during the night due to my back pain.
Walking the dog in the morning	8	It was a good activity to start the day. Being outside helped me to recharge my batteries.
Exercise in the gym	5	I didn't feel comfortable with all exercises. I had to stop working out because my back started to hurt.
Watching TV with my partner	7	Lying on the couch was relieving the pain. Talking to my partner about the day reduced my stress level.

Figure 2. Depiction of the first two pages of the reflective recovery diary. Page 1 entails the instructions, whereas page 2 portrays an exemplary diary entry for one day.

Second, several strategies were developed to enhance detachment as a process of physical and mental disengagement from work-related thoughts (Sonntag & Fritz, 2015). These

strategies were presented to the participants of the studies. The selection of detachment options including the specific strategies is portrayed in Figure 3.



*Figure 3.* Illustration of various detachment domains (bold and underlined) with exemplary detachment strategies.

The implementation of recovery strategies appears to be accompanied by a number of advantages such as the possibility to tailor the contents to individual needs, a high comprehensibility of the recovery tools, and low associated costs with recovery interventions. Given these perspectives in research, this dissertation incorporates three central research questions which were addressed in three consecutive studies. The synthesis of these findings should result in an evaluation of the effectiveness and feasibility of these recovery tools in prevention and rehabilitation settings.

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### **3.1 Are recovery-stress clusters associated with the quality of back pain?**

As a foundation for the subsequent studies that will be described in 4.2 and 4.3, the relationship between recovery-stress clusters and the BP parameters *Pain Intensity* and *Disability* should be analyzed. Previous research only underlined the predictive value of recovery-stress clusters of BP occurrence but did not elaborate on the subjectively perceived quality of BP. The aim of study 4.1 therefore consisted of the investigation of the link between recovery, stress, and BP. It was hypothesized that unfavorable patterns of low recovery and high stress were associated with higher *Pain Intensity* and *Disability*. The findings of this examination were intended to serve as a basis for the implementation of recovery tools into programs for BP prevention and rehabilitation.

### **3.2 Are recovery interventions effective in BP prevention?**

Preventive care for BP warrants individualized and person-specific psychosocial interventions to increase their effectiveness. Since both stress and recovery emerged as risk factors for BP, interventions targeting these domains could ameliorate BP through stress reduction and recovery enhancement. The integration of recovery interventions in terms of recovery tools (e.g., short exercises to enhance recovery) within prevention contexts could represent an approach to combine the idea of stress reduction and recovery enhancement. In addition, recovery interventions may delineate a feasible and potentially effective approach to reduce BP in secondary prevention. The aim of this study was to examine the influence of recovery tools on pain and disability in the spine within an out-patient prevention program (4.2). It was postulated that the recovery tools lead to a diminution in *Pain Intensity*, *Disability*, and *Stress* while improving psychological *Recovery*.

### **3.3 Are recovery interventions effective in BP rehabilitation?**

While BP prevention certainly characterizes an important factor to minimize the burden of BP, the majority of programs can be identified within BP rehabilitation. In accordance to the preventive perspective, the need for individualized and resource oriented psychosocial tools to decrease chronic BP also prevails in rehabilitation settings. The question was whether these recovery tools could be implemented within a multimodal rehabilitation program for BP and exhibit positive effects in terms of a reduction of chronic BP (4.3). It was assumed that the recovery tools would contribute to a decrease in the parameters *Pain Intensity*, *Disability*, and *Stress* and augment *Recovery* at the same time.

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## **4 Psychological recovery and back pain: Overview of peer-reviewed scientific publications**

### **4.1 Manuscript 1**

#### **Recovery-stress patterns and low back pain: Differences in pain intensity and disability**

Heidari, J., Mierswa, T., Hasenbring, M., Kleinert, J., Levenig, C., Belz, J., & Kellmann, M. (2018). Recovery-stress patterns and low back pain: Differences in pain intensity and disability. *Musculoskeletal Care*, *16*(1). doi: 10.1002/msc.1195

### **4.2 Manuscript 2**

#### **Evaluation of the effect of psychological recovery tools on back pain in an out-patient prevention program**

Heidari, J., Özen, E., & Kellmann, M. (2018). Evaluation of the effect of psychological recovery tools on back pain in an out-patient prevention program. *Work*. Advance online publication.

### **4.3 Manuscript 3**

#### **Evaluation of the short-term effects of recovery tools in the rehabilitation of chronic back pain: A feasibility study**

Heidari, J., Belz, J., Hasenbring, M., Kleinert, J., Levenig, C., & Kellmann, M. (2018). Evaluation of the short-term effects of recovery tools in the rehabilitation of chronic back pain: A feasibility study. *European Journal of Physiotherapy*. Advance online publication. doi: 10.1080/21679169.2018.1460397

## 5 Discussion

The aim of the present dissertation consisted of the examination of recovery in the context of BP from various perspectives. The first study (4.1) examined associations between recovery-stress clusters and BP (i.e., *Pain intensity*, *Disability*) using a cross-sectional design. The outcomes of this contribution served as a foundation to conduct the subsequent studies 4.2 and 4.3. Manuscript 4.2 discussed a study in a practical setting where the effects of psychological recovery interventions on BP parameters were tested in an out-patient prevention program in comparison to a control group without treatment. Finally, the context of BP rehabilitation was targeted in study 4.3. Patients with chronic BP received recovery tools in an out-patient rehabilitation program and the acute impact and feasibility of these recovery interventions on chronic BP alleviation was scrutinized. The following section will start with a specific discussion of the outcomes of each study while focusing on the strengths and limitations of each contribution. Subsequently, the full results of all three studies will be interpreted and discussed from a practical and applied point of view before a critical reflection and final conclusion related to the results of this dissertation will be presented.

### 5.1 Recovery, stress, and back pain

In contrast to recovery, stress has emerged as a consistent risk factor for BP over the years across various populations (Pincus et al., 2013; Taylor et al., 2014). Recovery in combination with stress only recently materialized as a potential risk factor for BP in a study by Mierswa and Kellmann (2017). Before that, recovery was examined in light of health complaints in general (Aronsson et al., 2013; Sluiter, de Croon, Meijman, & Frings-Dresen, 2003) as well as a restorative resource for work-related stressors (Sonnetag & Fritz, 2015; Sonnetag et al., 2010). Since the theoretical model proposed by Kellmann (2002) suggests an interrelatedness between stress and recovery, the rationale in study 4.1 stated that certain patterns of recovery and stress as a combined health indicator may be associated with the quality of BP. The outcomes of manuscript 4.1 outlined that both *Pain Intensity* and *Disability* were linked to recovery-stress patterns. In detail, high levels of stress together with low levels of recovery were associated with increased *Pain Intensity* and *Disability* in the back. Conversely, it could be demonstrated that low levels of stress in combination with high levels of recovery resulted in less *Pain Intensity* and *Disability*. These findings resemble those obtained by Aronsson et al. (2013) and extend the knowledge about BP specifically. It has to be noted that causality cannot be inferred from the findings of manuscript 4.1 but a mutual impact could be

established. The relationship between stress, recovery, and BP can be best described as a vicious circle (Truchon et al., 2008). There are two possible starting points for a detrimental health development in terms of consistent BP (Buckworth, Dishman, O'Connor, & Tomporowski, 2013). First, a lasting state of increased stress and reduced recovery due to external stressors (e.g., work obligations, social conflicts) may ultimately lead to a breakdown of muscle, tissue, and bone structures with increased pain sensitivity and muscle tension which promotes the onset of BP (Truchon et al., 2008). Second, BP caused by multiple microtraumas in combination with a disbalance in posture and muscular structures might be perceived as stressful and resource consuming. In case that downward spiral cannot be stopped adequately, stress, recovery, and BP may interact negatively and aggravate the condition of affected individuals until chronic BP manifests. These neurophysiological and psychological underpinnings might be the basis of our results and highlight the necessity to target stress and recovery through appropriate interventions in BP prevention and rehabilitation.

Critical remarks regarding the methodological approach of manuscript 4.1 also need to be addressed, since they influence the interpretation of the outcomes. The cross-sectional nature of the study has already been mentioned and prohibits causal inferences. An extension of the design to a prospective approach could allow conclusions towards the impact of recovery-stress patterns on pain development. A similar research paradigm was used in the study by Heidari et al. (2016) with a sample of athletes. Participants were divided into two groups in order to examine how *Recovery* and *Stress* could influence the course of BP over a six-month period. One group consisted of individuals with BP increase, the other had shown a decrease. This idea could be applied to the general population to identify longitudinal patterns of BP development in relation to *Recovery* and *Stress*. Another limiting factor targets the characteristics of the included sample in manuscript 4.1. The level of physical activity was comparably high in the overall sample and differed between the clusters. For this reason, physical activity was controlled for within the calculations but future studies should include physical activity as a moderator or mediator in the context of recovery and stress. Lastly, the methodological approach of using self-ratings of BP via measures of *Pain Intensity* and *Disability* should be estimated critically. A diagnosis via self-ratings appears to be the gold standard of pain assessment due to its comprehensibility, applicability, and scientific evaluation in terms of psychometric properties such as validity or reliability (Breivik et al., 2008). Nevertheless, the integration of behavioral tests (e.g., range of motion) or physiological markers should be warranted to reduce bias in pain reporting and to enable a

multidimensional assessment of BP if the circumstances allow their application. This would result in a more thorough assessment of the complex burden of BP and characterizes a less reductionistic procedure (Cowen, Stasiowska, Laycock, & Bantel, 2015).

Overall, the characteristics of the sample (i.e., all participants engaged in some form of physical therapy) may reduce the generalizability of the results to some extent, but it might also improve the meaningfulness of the results. Similar sample characteristics may be obtained in prevention and rehabilitation contexts where physical activity plays a crucial role during the treatment. The outcomes of manuscript 4.1 and other studies in the field were synthesized to form the basis for the manuscripts 4.2 and 4.3. Knowledge from different research findings was combined and relevant for the planning phase of the two subsequent studies of this dissertation. Mierswa and Kellmann (2017) showed that recovery-stress patterns may predict BP occurrence. Heidari et al. (2018) identified that dysfunctional patterns of *Stress* (i.e., high) and *Recovery* (i.e., low) were associated with more BP (i.e., *Pain Intensity, Disability*) and vice versa. Several other authors implied that recovery may exhibit a protective role on health issues and may be individualized to specific needs (Kellmann et al., 2018; Mierswa & Kellmann, 2015). As a consequence of these findings, the previously described recovery interventions were developed and were then examined with scientific methods in practical settings (Sonntag, 2003; Sonntag et al., 2010).

## **5.2 Recovery interventions in back pain prevention**

The implementation of preventive programs for BP characterizes an important step to impede the manifestation of BP as a chronic condition. By this means, a number of detrimental consequences such as long-term disability can be averted (Murray et al., 2012; Steffens et al., 2016). It is recommended to identify individualized psychosocial risk profiles for individuals on the verge of chronification in order to provide effective secondary prevention (Boersma & Linton, 2005). Despite the knowledge about the importance of such approaches, the current lack of convincing and scientifically validated programs lead to the evaluation of recovery interventions in an out-patient prevention program within manuscript 4.2. A total of 58 employees with BP were examined with 31 of them in the intervention group. The control group did not receive any treatment. After controlling for initial differences in sociodemographic parameters, the development of two processes was evaluated. First, the change of the BP parameters *Pain Intensity* and *Disability* was considered. Second, the effectiveness and feasibility of the recovery interventions was measured with the variables *Stress* and *Recovery*. Over a period of three months, *Stress* and the BP parameters *Pain*

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*Intensity* and *Disability* decreased within the intervention group, which indicates a favorable development. In contrast, the condition of the 27 individuals within the control group deteriorated, which was showed by an increase of these three variables. In addition, *Recovery* improved in the intervention group and diminished in the control group. The consistent positive development within the intervention group reflects the effectiveness of the recovery interventions conveyed to the 31 individuals within the out-patient prevention program. However, the specific outcomes of manuscript 4.2 are difficult to compare with other research findings. Al-Otaibi (2015) and Steffens et al. (2016) report that evidence on secondary prevention programs is scarcely represented in the literature. A rare example of scientifically validated secondary prevention programs epitomizes the study by Chaléat-Valayer et al. (2016). The researchers evaluated a global secondary prevention program for BP by randomizing 353 health care workers into two conditions. The intervention group received a combination of educational and physical interventions while the control group was provided with usual care. While the recurrence of BP after 24 months could not be reduced through the interventions, the intervention group reported less fear-avoidance beliefs and healthcare utilization after the intervention phase. Apart from that study, specific prevention programs to target BP reduction in out-patient settings could not be extracted. Therefore, the outcomes of manuscript 4.2 will primarily be discussed from a practical point of view. The recovery interventions were integrated into the regular routines of the prevention program as add-ons. In effect, the prevention program mainly consisted of machine-based physical training which was complemented by five interactive workshops during the three months of the program. These workshops were used to convey the recovery interventions which were organized in a systematic manner. Information about the interrelatedness between recovery and stress was given before presenting the reflective recovery diary and the detachment strategies as actual tools to foster recovery. It can be suggested that this sequential implementation of recovery elements over an extended period of time led to a sensitization for recovery as important facet for pain development. Consequently, individuals might have engaged in more recovery activities and thus healthier behavior (Kellmann et al., 2018; Young, 2014). Another advantage associated with the recovery interventions can be attributed to the possibility to individualize the content of the interventions. Both the reflective recovery diary and the detachment strategies emphasize recovery on a general level but allow each participant to choose a strategy that is relevant to them personally. For example, one may choose to engage in swimming as recovery strategy, while another person would focus on painting as a method to unwind. In preventive contexts, the level of disability through pain is moderate and such

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recovery activities can therefore be incorporated unproblematically. In effect, each participant was instructed to use the reflective recovery diary to identify his profile and preferences for certain recovery strategies. The actual recovery activity differs across individuals, but the consequence of the activity in terms of a recovery response and stress relief takes place equally. This may happen via increased self-efficacy and motivation to engage in the recovery strategies. These psychological processes are reported to exhibit beneficial effects on adherence to interventions, for example in physiotherapeutic contexts (McLean, Burton, Bradley, & Littlewood, 2010). Additionally, individuals with BP may appraise their condition differently after perceiving the recovery strategies as resources to deal with BP (Sonnetag & Fritz, 2015). Physiologically, the initiated relaxation response may trigger a number of positive processes related to pain relief such as reduction of inflammatory markers and improved immunological function (Buric, Farias, Jong, Mee, & Brazil, 2017; Schaffer & Yucha, 2004). While a combination of beneficial psychological and physiological processes might have resulted as a consequence of the recovery add-ons, some caveats should also be considered when interpreting these results.

The intervention group received considerable attention within the program in terms of individual strength training and the integrative workshops. Compared to that, the control group was only measured twice during the time span of the intervention without receiving any treatment. The intensive individual care and focus on the participants needs might have increased participants motivation and contributed to the overall improvement but was not assessed directly via questionnaires or interviews (Engers et al., 2008; Vong, Cheing, Chan, So, & Chan, 2011). Ideally, a comparison of the standard prevention program plus the add-ons to a standard treatment without additions would allow more definite conclusions regarding the effect of the add-ons. This drawback was addressed and eradicated within manuscript 4.3. Another factor which might have impacted and moderated the positive effects on BP is physical activity in the form of individualized machine training programs. A combined assessment of the psychosocial questionnaires and physical indicators was not administered in the study. Yet, it would have strengthened the generalizability of the outcomes and the overall message of the study. Training within the prevention program consisted of a combination of strength and flexibility exercises but their potential effect is not reflected distinctly in the data. Hayden, van Tulder, Malmivaara, and Koes (2005) report that these exercise elements show a positive effect on pain reduction in subacute BP. Despite these recommendations, a specific type of exercise and specific characteristics of the exercises (e.g., duration, frequency, intensity) cannot be provided based on the literature currently available

dealing with this topic. With regard to the design, we could not apply a randomization of the participants to the intervention and control group. Randomized controlled trials (RCT) are considered as gold standard in clinical research since they provide the best approach to minimize the influence of confounding variables and hence enable definite conclusions on the treatment effect (Bothwell, Greene, Podolsky, & Jones, 2016). Nevertheless, the conduction of RCTs in practical settings is rarely feasible which was also the case in manuscript 4.2 (Flory & Karlawish, 2012; Sullivan, 2011). The individuals in the study 4.2 voluntarily participated in the program which was supported by their company. The scientific evaluation needed to be included into the regular setting without creating an additional burden or organizational difficulties which would have been the case when designing a RCT.

### **5.3 Recovery interventions in back pain rehabilitation**

The need for individualization does not only exist in BP prevention, but also transfers to multimodal BP rehabilitation. Based on that rationale, the aim of manuscript 4.3 consisted in the evaluation of the effectiveness of recovery tools with regards to BP, stress, and recovery development within an out-patient rehabilitation program for individuals on sick leave due to chronic BP (4.3). A control group ( $n = 35$ ) receiving the standard treatment was compared to an intervention group ( $n = 20$ ) which was provided with the standard treatment and additional recovery tools. Due to the practical and realistic setting of the study, the feasibility aspect in terms of the applicability of the recovery tools into real-life rehabilitation programs was also considered. The analysis of acute outcomes (i.e., two weeks) reflected the idea to scrutinize feasibility via short-term effects. These outcomes were thought to be interpreted as preliminary results in light of the more profound paramount study which lasted 12-15 weeks in total. The low number of participants who completed the entire program prevented an analysis of all measurement points.

The results of the study do not favor the intervention group compared to the control group. Participants in both conditions benefited from the input in the first two weeks of the program. The BP parameters *Pain Intensity* and *Disability* decreased similarly across the groups. *Stress* also diminished in both groups. An increase of *Recovery* manifested in the control and intervention group, but was more pronounced in the intervention group. The baseline values regarding the outcome parameters did not show a significant difference between the groups which underlines the similar range of improvement measured in both conditions. These short-term effects do not corroborate the initial hypothesis that the recovery add-ons would exhibit a significantly greater effect on the outcome variables. Explanations for these findings aim at

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the nature of behavioral changes in general which also applies to the implementation of recovery strategies into daily routines. The analyzed two weeks probably represented a time frame that was too short to gather the full potential of the interventions. Many models of behavioral change discuss difficulties to even translate awareness of a problem into actual behavior since this process depends on many different factors (Michie, West, Sheals, & Godinho, 2018; Middleton, Anton, & Perri, 2013). Even if an intention leads to new behavior, this may take a considerable amount of time (Lally, van Jaarsveld, Potts, & Wardle, 2009). The imparted recovery tools might have initiated a sensitization for recovery as important aspect for BP and might have modified the perception of the participants towards their own resources. This initiation might be visible within the short-term data and should be monitored in order to assess whether a long-term behavior change occurred. In accordance with other relaxation techniques (e.g., mindfulness-based stress reduction), it takes some time to learn the recovery strategies and most importantly, use them on a regular basis (Carmody & Baer, 2009). If these fundamentals can be created with the recovery interventions, positive changes in BP may manifest via the relaxation response or psychological markers (e.g., self-efficacy). These effects may be observed during the program and may then be reflected statistically. An additional factor which might have impacted the results describes the amount of time available to deliver the recovery interventions. Only 10-15 minutes of the 90 minutes total duration of the individual sessions with the participants were reserved for the recovery tools. This amount of time might be considered as too short to initiate a change of perspective towards the recovery strategies. Patients with chronic pain conditions represent a sample that is difficult to treat and to communicate with (Matthias & Bair, 2010). Some patients might have required more time to understand the underpinnings of the recovery tools or may have required more time to recapitulate their strategies after using the reflective recovery diary. Apart from that, the control group received the identical treatment with a duration of 90 minutes which appears to have impacted the control group positively. This period of treatment allows an intensive care of the patient with a focus on individual needs resulting in a favorable development of BP. The relief in BP may have affected the decrease of stress and increase of recovery in the control group together with “soft” factors like attention or empathy. The combination of these effects might have contributed to the fact that a superior effect of the add-on condition could not be measured.

A number of limitations of manuscript 4.3 should also be addressed. Similar to the study described in manuscript 4.2, the course and principal elements of the rehabilitation program were planned and defined by the cooperating health care provider in collaboration with a

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number of health insurances in Germany. For this reason, the balancing act consisted of the integration of the recovery add-ons into the program without changing the schedule or favoring certain individuals. The study design was therefore predominantly based on a practical perspective and limited the autonomy to generate the highest standard of scientific evaluation (e.g., double blinding, strict inclusion and exclusion criteria, etc.). The issue of rigorous randomization raised in manuscript 4.2 could not be incorporated completely in manuscript 4.3 since the participants were treated in a rehabilitation center in proximity to their place of residence. Across the state North Rhine-Westphalia, six rehabilitation centers provided either the standard program or the recovery-plus program. The random allocation to either the control or intervention group based on the criterion of vicinity can be considered as ‘partial’ randomization which limits the influence of potential confounders. Another aspect targets the physiotherapists as facilitators of the interventions. Despite the fact that the physiotherapists in the intervention group received a thorough one-day training of the recovery tools by the principal investigator, variations regarding their implementation and contact with the participants may have occurred. Personal preferences for one recovery tool or a general skepticism about the topics recovery enhancement and stress reduction exemplify factors that may have influenced the way the recovery tools were conveyed. Adherence checklists and regular feedback regarding difficult situations were provided to counteract these confounders but the interpersonal differences might have impacted the implementation of the interventions regardless. This drawback reflects another example of the difficulty to coordinate practice and science. The physiotherapists formed an essential part of the program and worked with the patients. The researchers contributed background knowledge regarding the development and application of the recovery tools but were not able to directly interact with the patients in the rehabilitation setting.

#### **5.4 Paramount discussion of the results**

While each of the manuscripts 4.1-4.3 examined a selected research question with specific implications, the dissertation as an overall project should be discussed regarding its contribution and significance for the research field of psychosocial factors and BP. It can be stated that the three manuscripts within this dissertation follow a logical and sequential path and provide a preliminary picture of the applicability and potential effectiveness of recovery interventions in the context of BP. The evidence derived from these findings should be interpreted carefully in light of several methodological drawbacks inherent in the studies, but the innovative and promising approach developed and investigated within this dissertation

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should not go unnoticed. The studies reported in the manuscripts 4.2 and 4.3 delineate examples for a merge between practical application and scientific monitoring. On the one hand, there is a health care provider with a developed program and a clear conception of the procedures and components of either the prevention or rehabilitation program. On the other hand, researchers would wish for a rigorous study protocol with thorough randomization, inclusion and exclusion criteria, and self-monitored data collection and analysis. The common denominator of these two extremes needs to be identified while the interests of both parties should be considered. Manuscripts 4.2 and 4.3 delineate the result of these negotiations in terms of research designs which used the niches of the programs to test new approaches without modifying the predetermined overall construct and conception of the programs. The outcomes of the second and third study are therefore characterized by a high ecological validity. Difficulties in the implementation and suggested improvements derived from the results can be directly addressed within the program. Results from RCTs may provide less confounded results but their outcomes are hard to directly transfer to practical settings. The recovery tools and the psychometric diagnostics were directly embedded into the prevention (4.2) and rehabilitation (4.3) contexts to provide an add-on to the treatment as usual. The issue of confounding was considered within the last study of the dissertation where the recruited control group comprised participants who received the usual treatment without the recovery add-ons. The quasi-randomized distribution of the participants based on place of residence allowed more distinct conclusions about the potential effectiveness of the recovery interventions. In connection to the real-world evaluation of the programs, the issue of a sufficient sample size to acquire meaningful outcomes plays a role. Manuscript 4.1 gathered a sufficient sample size but described a cross-sectional study design without any intervention. The subsequent two studies in practical settings were subject to attrition and participant recruitment that was controlled externally by the health care providers. With analyzed sample sizes of  $N = 58$  (4.2) and  $N = 55$  (4.3), a generalization of the results and a definite conclusion on the effectiveness of the recovery tools in BP prevention and rehabilitation cannot be drawn. Reasons for these small sample sizes are manifold. Participation in both programs was on a voluntary basis and the participants were required to invest their spare time to facilitate the regular participation. From a preventive point of view especially, the willingness to maintain or even improve the health status before an illness or disease manifests represents a difficult task. The question why someone should invest resources without significant and prevalent health costs (e.g., BP is not limiting) is described in various health models such as the health belief model (Rosenstock, 1966). Only if the benefits of preventive behavior exceed

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the barriers to engage in preventive behavior, respective health-promoting actions are demonstrated on a regular and constant basis (Carpenter, 2010). Thought processes of that kind may have contributed to the attrition of participants across the prevention program. For the rehabilitation program, other reasons for the low number of participants might have been present. The sample in manuscript 4.3 consisted of individuals with severe chronic BP characterized by high disability and a resulting inability to work. These factors are associated with higher dropout and attrition rates in rehabilitation programs (Costa et al., 2009; Richmond & Carmody, 1999). Apart from that, chronic BP patients often display an extensive clinical history with numerous doctor visits which rarely led to an improvement of their condition (Thornton, 2011). These experiences shape their expectations and attitude towards a rehabilitation program and may promote a fast drop out in case their expectations are not met (Balagué et al., 2012; Cormier, Lavigne, Choinière, & Rainville, 2016). A combination of these effects is reflected in the reasons for dropout as reported in manuscript 4.3 and may have caused the considerable dropout rate of 24 % in the first two weeks of the program.

Another facet of methodological refinement which connects to dropout and the conservation of effects is the conduction of follow-up measurements. Aside from the immediate outcomes of the two programs, follow-up effects of the programs were not assessed within the included manuscripts of this dissertation. The evaluation whether the implemented recovery interventions triggered a lasting reduction of BP together with a permanent shift towards the perception of recovery as a resource represents a crucial aspect that needs to be considered. At the time of the completion of this dissertation, a sufficiently large number of participants for follow-up assessments could not be gathered. Obtaining information regarding the sustainability of the effects and potential barriers to consistently benefit from the recovery interventions has important implications for the participants and future research designs. A number of studies indicate that the majority of multidisciplinary prevention and rehabilitation programs for BP show short-term effectiveness but demonstrate deficits in the long-term (Gatchel et al., 2014; Kamper et al., 2015).

Furthermore, it should be discussed critically whether stress management and recovery enhancement represent distinct approaches to deal with individual health or if recovery enhancement simply delineates a relabelling of stress management. The former idea guided the development and evaluation of the recovery tools, since the focus on recovery is guided towards a resource-oriented and positively connoted approach to encourage individuals to find strategies to reduce their BP. In contrast, stress management aims at the reduction of negative

events or stimuli to alleviate stress through certain techniques. Nowadays, stress represents a constant companion individuals are confronted with at work or at home. This is not a genuinely bad thing and cannot be prevented in the majority of cases. As long as individuals know how to unwind, recover, and restore their capacities, stress can be adequately buffered which increases the positive responses to treatment in chronic BP (Gurung, Ellard, Mistry, Patel, & Underwood, 2015). Through the implemented recovery interventions within manuscripts 4.2 and 4.3, individuals were motivated to identify individual resources and use them to improve their health (i.e., reduce BP) which is reflected in the quantitative data. The perspective of considering recovery enhancement and stress reduction as intertwined but separate concepts is also revealed in other methods such as mindfulness-based stress reduction. Stress reduction is not directly targeted but rather facilitated through a strengthening of the personal resources. Recent research corroborated the short-term effectiveness of that approach in the treatment of BP (Anheyer et al., 2017).

Taken together, the outcomes of the dissertation support the effectiveness of recovery interventions. The results may serve as a starting point to modify the recovery approach with bigger samples and minor methodological modifications. The overall positive developments measured within manuscripts 4.2 and 4.3 can therefore be used as an argument for other health care providers to promote the integration of psychosocial tools of recovery with scientific monitoring to corroborate the findings. The practical nature of the outcomes in terms of feasibility and adaptability to existing health programs make them especially valuable at the interface between science and practice.

## **5.5 Critical reflection of the status quo in back pain research**

When entering the term “back pain” into the search mask of PubMed, 63.266 results, dating back to the year 1912, are identified. Despite this abundance of research produced in the field of BP for more than 100 years, the issue of BP continues to affect more and more people (Hoy et al., 2012; Hoy et al., 2010; Murray et al., 2012). For this reason, researchers continue to increase the knowledge about BP and aim to develop effective interventions applicable to a wide range of individuals suffering from BP. Broad consensus exists regarding the complexity of BP as a biopsychosocial phenomenon which requires biopsychosocial elements in both prevention and rehabilitation (Pincus et al., 2013). This biopsychosocial rationale should not only be included during the program as part of the intervention elements, but already during the diagnostic phase in terms of risk factor screenings. In effect, the diagnostic procedure should consist of a combination of physical examinations (e.g., history of BP) and a stratified

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assessment of psychosocial risk factors in order to provide individualized treatments based on the risk profile of each patient (Chou et al., 2007; Wippert et al., 2017). While this approach represents best practice, the systematic synthesis of evidence-based knowledge from various disciplines and their scientifically supported implementation into real life settings is accompanied by several problems. To illustrate the remaining difficulties of how to connect biomedical, biomechanical, and psychosocial research into a comprehensive treatment with a paramount message, an example of personal experience will be presented. My PhD data were acquired within the joint project *National Research Network for Medicine in Spine Exercise (MiSpEx)* which unifies numerous research units located across Germany. From 2011 to 2018, experts with biomechanical, medical, psychological, and sport-scientific background aimed to identify, design, and evaluate biopsychosocial diagnostics and interventions for BP prevention and rehabilitation for non-athletes and athletes. Although many years of investigation with abundant results and meetings have passed, the consortium is still not able to make definite statements and conclusions regarding the ideal dose, content, and duration of exercise interventions complemented by a psychosocial screening and treatment. Even if the required expertise for effectively treating BP is existent in theory, the cooperation and integration of this swarm intelligence remains a significant barrier. Instead of planning and designing studies and interventions together, it rather happens that each of the parties is starting to work separately and in the end, all research units try to merge their findings. For instance, physical activity and respective exercise elements formed an important part of all three studies conducted within this dissertation. Nevertheless, the effect of exercise, although considered as very important, was not evaluated in these studies due to the lack of competence. If a sport-scientific expert had been included in all phases of the studies, potential modifications in the exercise interventions could have been incorporated and analyzed which might have increased the overall effectiveness of the programs and hence the meaningfulness of the outcomes.

This status quo appears to be prevalent in many multimodal programs which lack the specific biopsychosocial expertise in terms of a team of specialists (i.e., doctors, psychologists, and physiotherapists) to conduct the diagnostics, convey the interventions and draw conclusions from the collected data (Kamper et al., 2015; Reese & Mittag, 2013). The investment of such extensive resources seems to be considered as uneconomical and cost-intensive. It can be argued that the effectiveness of such an - in fact - multidisciplinary approach with initial high investment should be weighed against the potential long-term positive outcomes it may have. Patients receiving an individualized intervention provided by a group of experts may benefit from such an input in terms of reduced disability, knowledge about pain management, and a

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sustainable increase in quality of life overall. These individuals will subsequently require less healthcare costs and will be able to return to work. Additionally, the ideal relationship of dose, content, and total duration of treatment can be assessed by the multidisciplinary team resulting in more beneficial outcomes for the patients (Waterschoot et al., 2014). This procedure would delineate a bridge between research and practice in BP prevention and rehabilitation which appears to be the most reasonable approach to engage in. Research needs to provide validated techniques and instruments which can then be adapted and implemented in practice based on the expertise of the multidisciplinary staff. As prerequisites, a multidisciplinary staff has to be present and most importantly, all experts have to equally accept the significance of bio-psycho-social treatment elements and subsequently convey that attitude to the patients.

Another probably more cost-effective option to integrate the biopsychosocial rationale into prevention or rehabilitation settings was pursued in manuscript 4.3. In the context of that study, the concept of educating and training practitioners (i.e., physiotherapists) in a field they are not familiar with was implemented. Physiotherapists received scientific input (i.e., recovery tools) from psychological experts and transferred these ideas into a practical setting. Thus, biopsychosocial interventions for BP rehabilitation were administered by one professional group which was thoroughly instructed by experts from another field. This procedure could be adapted to other study settings where psychologists receive a profound training in functional testing or basic physiotherapeutic exercises. While psychologists will never be able to convey these exercise interventions at the same quality level as physiotherapists, at least some form of biopsychosocial input could be generated with a comparatively small investment. Looking at it from the opposite perspective, the question remains whether physiotherapists can be educated sufficiently to provide a high level psychological knowledge. A potential solution to these drawbacks may consist of a continuous monitoring of physiotherapists with feedback sessions provided by the psychological experts in order to guarantee a high standard of the psychosocial interventions.

Moreover, a time-saving step towards the integration of biopsychosocial screenings into practical settings could consist of smartphone applications. Patients could use their time in the waiting rooms of doctors to complete a psychosocial screening which is analyzed automatically. Data to categorize patients based on their risk profile could guide practitioners' treatment suggestions and consequently improve treatment outcomes. First steps towards the creation and evaluation of such screening instruments have already been taken (Hill et al.,

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2008; Mehling, Avins, Acree, Carey, & Hecht, 2015). While Karran et al. (2017) indicate that these screening tools entail little predictive and discriminative value, they still represent a promising option to be implemented in practical settings if they are further modified and specified. This could also be extended to the use of smartphone applications as support for regular treatment or as a possibility to promote self-management of BP. As caveat, Machado et al. (2016) point out that the clinical effectiveness of the majority of the existing applications has not been examined so far. It is suggested that researchers and application developers should cooperate more closely to design evidence-based applications for the prevention and treatment of BP.

During the dissertation, another field of research in relation to BP was explored which should be briefly discussed as a final aspect in the context of BP treatment. Individualization is a noble goal in the treatment of all diseases and health issues but will perhaps never be achieved completely. An alternative to a less rigorous degree of individualization is denoted by the assessment of cohort specific risk factors and subsequent interventions. For example, a considerable discrepancy in a variety of characteristics is prevalent between the general population and competitive athletes. Non-athletes and athletes differ in the perception of pain, experienced mechanical loads, or psychological characteristics to name but a few (Foss, Holme, & Bahr, 2012; MacNamara, Button, & Collins, 2010; Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012). These factors also affect the onset and course of BP between these two demographics. Heidari and colleagues focused on the examination of stress and recovery as potential risk factors in BP and found that some facets of stress were associated with the presence of BP as well as with the chronification of BP (Heidari, Belz, et al., 2017; Heidari, Hasenbring, Kleinert, & Kellmann, 2017; Heidari et al., 2016). Gathering such population specific information should be regarded when designing interventions for a particular demographic. For athletes, risk factors and interventions can even be scrutinized for specific sport disciplines to further improve the fit between population needs and strategies to help the individuals to deal with BP.

Although manifold research on BP has emerged across decades, the complexity and multifacetedness of the phenomenon rarely allows conclusions that are applicable to all individuals. Rather, science should provide an evidence-based pool of knowledge, information, and tools that should be applied and modified in practice based on individual circumstances and requirements.

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## 6 Conclusion

Two questions that remain are: first, the question about what can be derived from the results obtained in this dissertation when interpreted in light of the overall research findings on psychosocial factors associated with BP; second, the question whether recovery is now the one key factor to definitely consider within the context of BP.

Obviously it is a presumptuous postulation that recovery activities represent the breakthrough in psychosocial BP research. To put the outcomes of this dissertation into perspective, the implementation of recovery appears to be another beneficial approach to bring relief to BP patients. Integrating recovery tools into BP prevention and rehabilitation demarcates a small but meaningful piece in the complex puzzle BP. Although there is seemingly endless research on the contribution of psychosocial factors for BP onset and chronification, it still cannot be determined which factors are the most important, how they interact, and how they impact the prognosis of BP (Nicholas et al., 2011; Pincus et al., 2013). The strengths of recovery interventions lie in their adaptability to individual needs and their relatively high intuitive comprehensibility. Hence, the gathered evidence on the effect of recovery tools could serve as a starting point for further research in different settings with different samples and possibly modifications with regards to duration and content. Most importantly, the psychosocial component recovery needs to be combined with exercise-based interventions and a thorough biomedical examination. Ultimately, the biopsychosocial paradigm is the foundation to successfully fight BP and should be internalized by all experts who are aiming to help individuals suffering from BP.

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## Appendix

### A Explanation of the author contributions for the publications

#### *A1 Contributions of Jahan Heidari as author of the dissertation*

Jahan Heidari developed the research questions, carried out the literature searches and was leading the design and conduction of the studies as well as the collection and statistical analyses of the data. In addition, Jahan Heidari wrote the first drafts of the manuscripts, revised the manuscripts based on the co-author feedback and submitted the manuscripts to scientific journals. He also incorporated the reviewer feedback obtained from the journals and communicated with the journal editors during the publication process.

#### *A2 Contributions of the co-authors*

Prof. Dr. Michael Kellmann, Prof. Dr. Jens Kleinert, Prof. Dr. Monika Hasenbring, Johanna Belz, Tobias Mierswa and Claudia Levenig supported Jahan Heidari with suggestions in terms of language, structure, and content and thereby helped to increase the quality of the manuscripts. All co-authors co-operated to develop a suitable study design for study 3, while Johanna Belz and Claudia Levenig also assisted in the data collection. Ersan Özen facilitated the implementation of study 2 as a field study and served as contact person during the study.

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**B Overview of additional scientific contributions during the PhD studies****B1 List of additional peer-reviewed journal articles during the PhD studies**

- Belz, J., Heidari, J., Levenig, C., Hasenbring, M., Kellmann, M., & Kleinert, J. (2018). Stress and risk for depression in competitive athletes suffering from back pain – Do age and gender matter?. *European Journal of Sport Science*. Advance online publication. doi: 10.1080/17461391.2018.1468482
- Heidari, J., Beckmann, J., Bertollo, M., Brink, M., Kallus, K. W., Robazza, C., & Kellmann, M. (2018). Multidimensional monitoring of recovery status and implications for performance. *International Journal of Sports Physiology and Performance*. Advance online publication. doi: 10.1123/ijsp.2017-0669
- Heidari, J., Belz, J., Hasenbring, M., Kleinert, J., Levenig, C., & Kellmann, M. (2017). Examining the presence of back pain in competitive athletes: A focus on stress and recovery. *Journal of Sport Rehabilitation*. Advance online publication. doi: 10.1123/jsr.2017-0235
- Heidari, J., Hasenbring, M., Kleinert, J., & Kellmann, M. (2017). Stress-related psychological factors for back pain among athletes: Important topic with scarce evidence. *European Journal of Sport Science*, 17, 351-359. doi: 10.1080/17461391.2016.1252429
- Heidari, J., Mierswa, T., Hasenbring, M., Kleinert, J., Levenig, C., Ott, I., & Kellmann, M. (2016). Low back pain in athletes and non-athletes: A group comparison of basic pain parameters and impact on sports activity. *Sport Sciences for Health*, 12, 297-306. doi: 10.1007/s11332-016-0288-7
- Heidari, J., Mierswa, T., Kleinert, J., Ott, I., Levenig, C., Hasenbring, M., & Kellmann, M. (2016). Parameters of low back pain chronicity among athletes: Associations with physical and mental stress. *Physical Therapy in Sport*, 21, 31-37. doi: 10.1016/j.ptsp.2016.03.003
- Kellmann, M., Bertollo, M., Bosquet, L., Brink, M., Coutts, A. J., Duffield, R., . . . Beckmann, J. (2018). Recovery and performance in sport: Consensus statement. *International Journal of Sports Physiology and Performance*, 13, 240-245. doi: 10.1123/ijsp.2017-0759
- Pelka, M., Heidari, J., Ferrauti, A., Meyer, T., Pfeiffer, M., & Kellmann, M. (2016). Relaxation techniques in sports: A systematic review on acute effects on performance. *Performance Enhancement & Health*, 5, 47-59. doi: 10.1016/j.peh.2016.05.003

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**B2 List of book chapters during the PhD studies**

Heidari, J., & Kellmann, M. (in press). Recovery. In D. Hackfort, R. Schinke & B. Strauss (Eds.), *Dictionary of Sport Psychology*. Amsterdam, NL: Elsevier.

Heidari, J., Kölling, S., Pelka, M., & Kellmann, M. (2018). Monitoring the recovery-stress state in athletes. In M. Kellmann & J. Beckmann (Eds.), *Sport, recovery and performance: Interdisciplinary insights* (pp. 3-18). Abingdon, UK: Routledge.

**B3 List of conference contributions (talk or poster) during the PhD studies**

- Heidari, J., Belz, J., Hasenbring, M., Kleinert, J., Levenig, C., & Kellmann, M. (2018). How do recovery tools work within chronic back pain rehabilitation? Evaluation of short-term effects from a feasibility perspective. In U. Borges, L. Bröker, S. Hoffmann, T. Hosang, S. Laborde, R. Liepelt, B. Lobinger, J. Löffler, L. Musculus & M. Raab (Eds.), *Psychophysiology and action: Book of abstracts of the 50th annual congress of the German Society of Sport Psychology* (p. 24). Cologne, GER: German Sport University Cologne.
- Heidari, J., Belz, J., Hasenbring, M., Kleinert, J., Levenig, C., & Kellmann, M. (2017). Stress und Erholung als Risikofaktoren für Rückenschmerz bei Leistungssportlern [Stress and recovery as risk factors for back pain in competitive athletes]. In C. Zuber, J. Schmid, M. Schmidt, M. Wegner & A. Conzelmann (Eds.), *Successful development across the lifespan: Book of abstracts of the 49th annual congress of the German Society of Sport Psychology* (pp. 48-49). Bern, CH: University of Bern, Bern Open Publishing.
- Heidari, J., Hasenbring, M., Kleinert, J., & Kellmann, M. (2017). Overview of the relationship between psychological stress and back pain among athletes. In A. Ferrauti, P. Platen, E. Grimmering-Seidensticker, T. Jaitner, U. Bartmus, L. Becher, M. De Marées, T. Mühlbauer, A. Schauerte, T. Wiewelhove & E. Tsolakidis (Eds.), *Book of Abstracts of the 22nd Annual Congress of the European College of Sport Science* (p. 214). Cologne, GER: European College of Sport Science.
- Heidari, J., Mierswa, T., Hasenbring, M., Kleinert, J., Levenig, C., Belz, J., & Kellmann, M. (2016). Pain and disability in the lower back: What role do recovery-stress patterns play? In M. Hasenbring & P. Platen (Eds.), *Book of Abstracts of the Mind and Pain in Motion Symposium* (p. 17). Bochum, GER: Ruhr University Bochum.
- Heidari, J., Mierswa, T., Kleinert, J., Ott, I., Levenig, C., Hasenbring, M., & Kellmann, M. (2016). Chronic low back pain among athletes: How is it related to physical and mental stress? In M. de Bruin, N. Pearce, F. Sniehotta, T. Turnbull & C. Cooper (Eds.), *Book of abstracts of the European Health Psychology Society and British Psychological Society Division of Health Psychology Conference (EHPS/DHP)* (p. 377). Aberdeen, UK: EHPS/DHP.
- Heidari, J., Özen, E., & Kellmann, M. (2016). Psychologische Aspekte in der Prävention von Rückenschmerz: Integration von Erholungsbausteinen im Betsi-Programm bei medicos.AufSchalke [Psychological aspects of back pain prevention: Integration of

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recovery tools into the Betsi program at medicos.AufSchalke]. In B. Halberschmidt, D. Dreiskämper, T. Utesch, M. Tietjens, K. Staufenbiel, L. Schücker, M. Kolb, S. Querfurth, S. Menzel, A. Hill, C. Raue & B. Strauß (Eds.), *Peak performance and sport psychology in light of the Olympics: Book of abstracts of the 48th annual congress of the German Society of Sport Psychology*. Münster, GER: asp.

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**Statutory declaration (Eidesstattliche Erklärung)**

Hiermit erkläre ich an Eides statt, dass ich die vorliegende Dissertation selbst und ohne unerlaubte fremde Hilfe angefertigt habe. Außer den im Literaturverzeichnis genannten Hilfsmitteln wurden keine weiteren verwendet. Alle ganz oder annähernd übernommenen Textstellen sowie verwendete Grafiken wurden entsprechend der Richtlinien kenntlich gemacht. Außerdem versichere ich, dass die vorgelegte elektronische mit der schriftlichen Version der Dissertation übereinstimmt und ich keine kommerzielle Beratung oder Vermittlung in Anspruch genommen habe. Weiterhin erkläre ich, dass ich an der Fakultät für Psychologie der Universität Konstanz den Master of Science im Fach Psychologie erworben habe, um mich für dieses Dissertationsvorhaben zu qualifizieren. Darüber hinaus habe ich keine weiteren staatlichen oder akademischen Prüfungen absolviert. Zuletzt erkläre ich, dass ich diese Dissertation zur Erlangung des Doktorgrades der Philosophie in der Fakultät für Sportwissenschaft eingereicht habe. Darüber hinaus habe ich diese Arbeit weder in der gegenwärtigen noch in einer anderen Fassung in anderen Fakultäten vorgelegt.

Bochum, den 05.06.2018

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Jahan Heidari