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Effects of supplemental heat therapy in multimodal treated chronic low back pain patients on strength and flexibility

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ABSTRACT

Background: The beneficial effects of thermotherapy on analgesia and relaxation are widely known for various diseases. To date, however, thermotherapy in chronic low back pain is not explicitly recommended in international guidelines. The effects of thermotherapy on biomechanical parameters within a multimodal back pain treatment concept are also unknown.
Methods: Within a multimodal treatment concept, 176 patients with chronic low back pain were treated either with or without supplemental heat wrap therapy. The range of movement and strength parameters of the trunk in flexion, extension, lateral flexion and rotation were measured before and after 12 weeks of treatment.
Findings: The range of movement as well as strength parameters of the trunk improved on average within the multimodal treatment. Patients receiving additional thermotherapy supplemental to basic multimodal treatment showed a further improvement of strength parameters regarding extension ($P = 0.09$, $1 - \beta = 0.41$), rotation to the right ($P = 0.09$, $1 - \beta = 0.41$) and rotation to the left ($P = 0.08$, $1 - \beta = 0.42$) in comparison to those conducting only the multimodal treatment. No group differences were detected in flexibility.
Interpretation: The implementation of thermotherapy for several hours a day (heat wrap therapy) in daily clinical practice additional to an individualized, evidence-based multimodal treatment concept can be recommended to enhance strength parameters. The potential causes of improved strength parameters as well as the meaning for the patients in activity of daily living are discussed.

1. Introduction

With approximately 84% of the adult population affected, low back pain (LBP) is one of the most common health problems worldwide and the leading cause for activity limitation and absence from work (Balague et al., 2012; Hoy et al., 2014; Lidgren, 2003). Annual incidence rates from 1.5% in Kuwait to 36% in the United Kingdom are reported for any episode of LBP, the overall prevalence of LBP ranges from 49 to 70% in the western countries (Hoy et al., 2010). For chronic LBP (cLBP), authors of the current European Union (EU) guidelines estimate a prevalence of about 23% in the EU (Airaksinen et al., 2006). In the United States (US), a point prevalence of 13.1% in adults from 20 to 69 years was reported in 2009–2010 (Shmagel et al., 2016). The socioeconomic impact associated with LBP caused by prolonged loss of function, inability to work and medical resource utilization (MRU) is high. Annually accruing costs have been estimated at $ 100 billion in the US and up to € 8.4 billion in Germany (German Medical Association [BÄK] et al., 2017).

The pathogenesis of LBP is not entirely clear. The reasons are complex and include structural, physiological, psychological and social components (Liang et al., 2012; Liang et al., 2013; Schneider et al., 2005; Schneider et al., 2006; Schneider et al., 2007).

One presumed aspect in the development of back complaints in humans is the evolutionary development from quadrupedal locomotion to bipedalism (Jurmain, 2000; Latimer, 2005). The lumbar spine is exposed to a high compressive force acting down the long axis of the spine (Adams, 2004; Kirkaldy-Willis and Bernard, 1999). By walking upright, intervertebral discs remain compressed as compared to a balanced bending and compression in animals with quadrupedal locomotion. Probably, this effect is one reason accounting for enhanced intervertebral disc problems and low back pain in modern civilisation. In fact, humans display substantially more degenerative and traumatic

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spinal pathologies than non-human primates, which supports the hypothesis (Jurmain, 1989, 2000; Lovell, 1990).

Intervertebral discs, separating the adjacent vertebral bodies, contain a deformable cushion and ensure an even distribution of the compressing load on to the vertebrae (Adams, 2004; Kelsey et al., 1984). On the one hand, due to the high load and repetitive strain in everyday as well as sports activities, the lower back is prone to acute injuries and permanent impairments (Berger-Roscher et al., 2017; Bergmann et al., 2017; Fett et al., 2017; Trompeter et al., 2016; Wilke et al., 1999; Wilke et al., 2014); on the other hand, disc cells and bony structures must be exposed to mechanical loads to positively impact the structures and the biochemical environment as well as to regulate the disc matrix turnover (Neidlinger-Wilke et al., 2006; Neidlinger-Wilke et al., 2014).

Besides structural damage, inflammation of the lumbar tissue can lead to higher concentrations of calcitonin gene-related peptide (CGRP) and substance P (SP)-containing free nerve endings and to their sensitization. Inflammation of muscles or connective tissue such as fascia, are also discussed as triggers of LBP in damaged and undamaged tissues (Adams, 2004; Hoheisel et al., 2012; Hoheisel and Mense, 2015; Liang et al., 2012; Liang et al., 2013; Tesarz et al., 2011; Weinkauf et al., 2015). These processes may result in pain, weakness of the trunk muscles and restricted flexibility of the spine (Hakkinen et al., 2003a; Hakkinen et al., 2003b).

At present, the most effective and evidence-based therapy for cLBP is a multimodal, interdisciplinary treatment including medical and physiotherapeutic treatment using strength-training devices as well as social and psychological support (Muller-Schwefe et al., 2017; Oliveira et al., 2018; Pfingsten et al., 1997). However, the underlying mechanisms are unclear (Bredow et al., 2016; Chou and Huffman, 2007; Koes et al., 2010; Norlund et al., 2009; van Middelkoop et al., 2011; van Tulder et al., 2003).

The effects of heat therapy with regard to LPB have not yet been sufficiently investigated, although heat therapy has been favored for centuries in the treatment of various medical conditions and in self-treatment, e. g., in form of balneotherapy or fango packs on pain relief, increased blood flow, relaxation, strength and flexibility (French et al., 2006; Michlovitz et al., 2011).

Under this background, there is a research deficit for the exclusive treatment with thermotherapy as well as for thermotherapy additional to standard therapy or a multimodal therapy for LBP (Airaksinen et al., 2006; Dagenais et al., 2010; Delitto et al., 2012; French et al., 2006; German Medical Association [BÄK] et al., 2017; Koes et al., 2010; Last and Hulbert, 2009; National Collaborating Centre for Primary Care, 2009; Philadelphia Panel Members, 2001; van Tulder et al., 2006).

Changes in biomechanical parameters such as strength and flexibility represent valuable outcome parameters for the effectiveness of thermotherapy within a multimodal treatment concept (MTC), since they are closely related to the function of the spine, activities of daily living as well as the perceived pain (Alfuth and Cornely, 2016; Alfuth and Welsink, 2017). Therefore, the aim of the present study was to evaluate the influence of supplemental heat on strength and flexibility in cLBP patients within a MTC by determining the range of movement (RoM) and strength parameters of the trunk in flexion, extension, lateral flexion and rotation.

2. Methods

2.1. Study design

The present randomized, active controlled, multi-center, investigator-blinded observational study was performed in six different physiotherapy centers (NOVOTERGUM AG, Essen, Germany) with a standardized multimodal treatment concept (Freiwald and Krajewski, 2010) from January 05 until June 30, 2014.

In compliance with the ethical guidelines of the 1975 Declaration of Helsinki, the study was approved and accepted by the Ethic Committee of the University of Wuppertal, Germany. (approved by written communication, October 19, 2011).

2.2. Inclusion and exclusion criteria

The patients were recruited from out-patient physiotherapy centers by the referring physicians based on the cLBP diagnosis (ICD M40-54). Patients were eligible for inclusion in the study in case of prolonged inability to work due to back pain as classified by the *International Statistical Classification of Diseases and Related Health Problems*, 10th revision German Modification Version 2016 (ICD-10-GM) as M40-M54, the existence of more than six months' persistent atraumatic back pain and severe limitations in daily life functions and an age of 18–55 years. Another inclusion criterion was an *Oswestry Low Back Pain Questionnaire* index (ODI) with $\leq 41\%$ (i.e., a moderate disability).

Excluded were patients, suffering from back pain caused by, or related to, any clinically or multi-system medical diseases (e. g., multiple myeloma, metastatic carcinoma).

2.3. Participants and course of the study

The patients' demographic and anthropometric baseline characteristics, such as age, weight, body mass index (BMI), selected data from medical history as back complaints, back complaint duration, visits to the doctor, days unfit to work, sick leave and days in hospital were determined at the first study visit (pre-treatment, t0). At the first examination and treatment unit, 176 patients were randomly assigned in chronological order into the MTC group and the MTC & heat wrap group in a 1:1 ratio (Table 1). After 12 weeks of standardized multimodal back pain treatment with or without supplemental heat wrap therapy, a second, final examination was conducted. Standardized documentation of patient data (pre-treatment, t0; post-treatment, t1) was carried out. For an overview of the study flow see Fig. 1.

2.4. Multimodal treatment concept

The multimodal treatment concept included a therapeutic conversation at first treatment unit and standardized documentation of patient's history. Both study groups were treated within a highly

Table 1
Demographic and baseline characteristics of patients.

	MTC & heat wrap group n = 88		MTC group n = 88	
	Mean (SD)	Range	Mean (SD)	Range
Demographic and anthropometric characteristics				
Age (years)	41.4 (8.2)	22–55	41.6 (8.3)	23–55
Male/female (n)	38/50		40/48	
Weight (kg)	79.6 (15.1)	50–110	80.0 (19.5)	49–155
Height (cm)	173.9 (8.6)	155–190	174.3 (9.3)	153–199
BMI (kg/m^2)	26.0 (4.3)	18–37	26.0 (5.4)	18–49
Medical history				
Back complaints (%)	100 (0)		100 (0)	
Back complaint duration (years)	7.3 (7.6)		7.1 (6.9)	
Back pain days (n)	84.9 (17.4)		82.0 (19.6)	
Visits to the doctor (n)	6.92 (7.99)		7.65 (10.97)	
Days sick leave (n)	11.1 (18.8)		11.8 (21.3)	
Days in hospital (n)	1.8 (6.2)		1.7 (6.9)	
ODI (%)	31.4%		30.9%	
ODI (max 45 points)	14.13 (5.45)		13.90 (6.06)	

BMI = Body mass index; LBP = Low back pain; ODI = Oswestry Low Back Pain Disability Index; SD = Standard deviation.

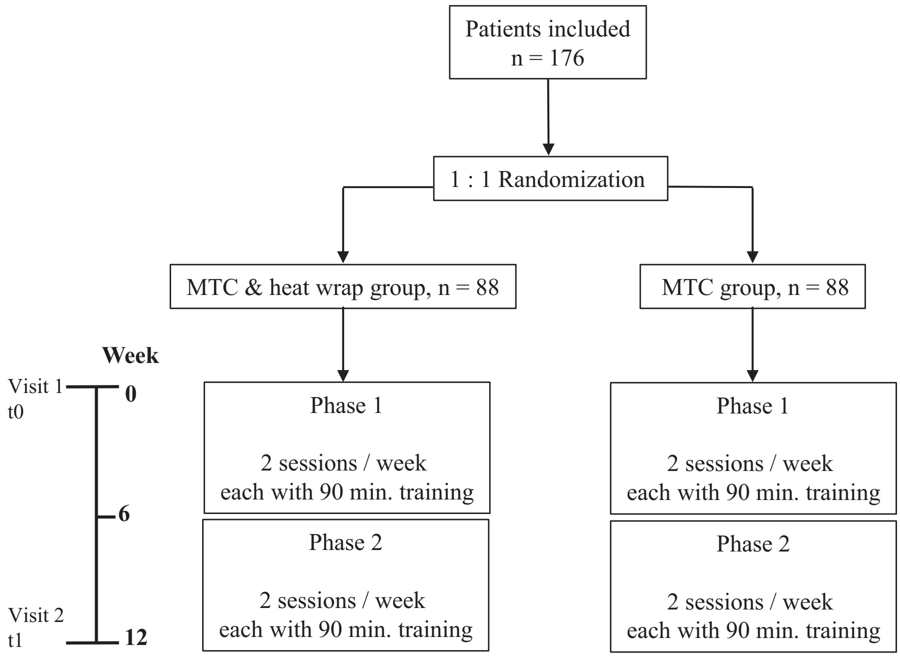

Fig. 1. Overview of study flow. The multimodal treatment was carried out in two phases of six weeks, with 2 units each with 90 min therapy and training per week in phase 1, and 1–2 units each with 90 min therapy and training per week in phase 2.

standardized MTC under supervision of qualified physicians, physiotherapists, sports therapists and (on request) psychologists, whereby treatments were conducted according to interdisciplinary and multimodal treatment strategies for cLBP patients (Freiwald and Beermann, 2010).

Regarding the time schedule, the multimodal treatment was carried out in two phases of six weeks, with two units each with 90 min therapy and training per week in phase 1, and 1–2 units each with 90 min therapy and training per week in phase 2 (Fig. 1). The absolute number of treatments did not differ between both groups. Intensity and frequency of the therapy and training load for the second phase were determined according to patients baseline characteristics (t0) and individual response to therapy and training (Details in Freiwald et al., 2011).

The training units consisted of (i) warming-up, (ii) stretching, (iii) equipment-based training, (iv) cooling down and extension followed by (v) treatment with paraffin heat carriers at 50–60 °C for the duration of 20 min, adjusted over the entire length of the spine (Rennie and Michlovitz, 2012). The heat wrap group received a supplemental heat wrap with a target temperature of 40 °C (mild heat) over 8 h (ThermaCare®, Pfizer Consumer Healthcare GmbH, Berlin, Germany) to be worn on the lower back according to the manufacturer's instructions. The heat wraps were applied directly after the multimodal treatment and had to be worn the following night; a second device was applied on the consecutive day, respectively.

2.5. Outcomes

The primary outcome of the study was the effect of the supplemental heat wrap therapy (MTC & heat wrap) within a MTC as determined by muscular strength (torque) and flexibility (RoM) of the trunk.

2.5.1. Assessment of baseline characteristics

All baseline characteristics, demographic as well as anthropometric patient data and medical history were collected at the beginning of therapy (t0) in a standardized form. The impairment in quality of life due to LBP was determined using the validated ODI (Fairbank et al., 1980; Neubauer et al., 2006).

2.5.2. Assessment of biomechanical parameters

For the assessment of the patient's biomechanical parameters, all examinations were conducted in a standardized way after familiarization of the patients with the use of the training stations (*SCHNELL* Trainingsgeräte GmbH, Peutenhausen, Germany; Fig. 2). The assessment was performed at study start (t0) and after 12 weeks of multimodal treatment (t1) for each patient. The training devices were equipped with sensors for measuring angular velocity and force from which torque was derived in accordance to the legal licensing requirements (EC directive medical devices 93/42/EEC). Calibration was carried out in the legally prescribed intervals; measurement inaccuracies were < 1° or < 1 N, respectively.

The measured torque of the trunk was normalized to the respective patient upper body mass according to Zaciorskij et al. (1984)). In general, all patients received standardized instructions for usage of the devices and were positioned in the devices under supervision of a qualified physiotherapist. All measurements were performed at least twice, the respective highest value was used for statistical analysis.

2.5.2.1. Measurement of the flexibility. The flexibility of the trunk was measured in the flexion, extension, rotation, and lateral flexion defined as the maximum RoM.

2.5.2.1.1. RoM in flexion and extension. Patients were positioned in the device (Fig. 2 A, B) with an assumed virtual axis of rotation at the level of lumbar segments L3-L4 with a hip angle of 75–80°.

2.5.2.1.2. RoM in lateral flexion. Patients were fixed in the device (Fig. 2 C) so that lateral movement was only possible through the thoracic and lumbar spine.

2.5.2.1.3. RoM in rotation. Patients were fixed in the device (Fig. 2 D) so that rotational movement was only possible through the thoracic and lumbar spine.

2.5.2.2. Measurement of the strength. The muscular strength of the trunk was measured in the flexion, extension, rotation and lateral flexion defined as the maximum isometric torque.

2.5.2.2.1. Torque in flexion and extension. Patients were positioned

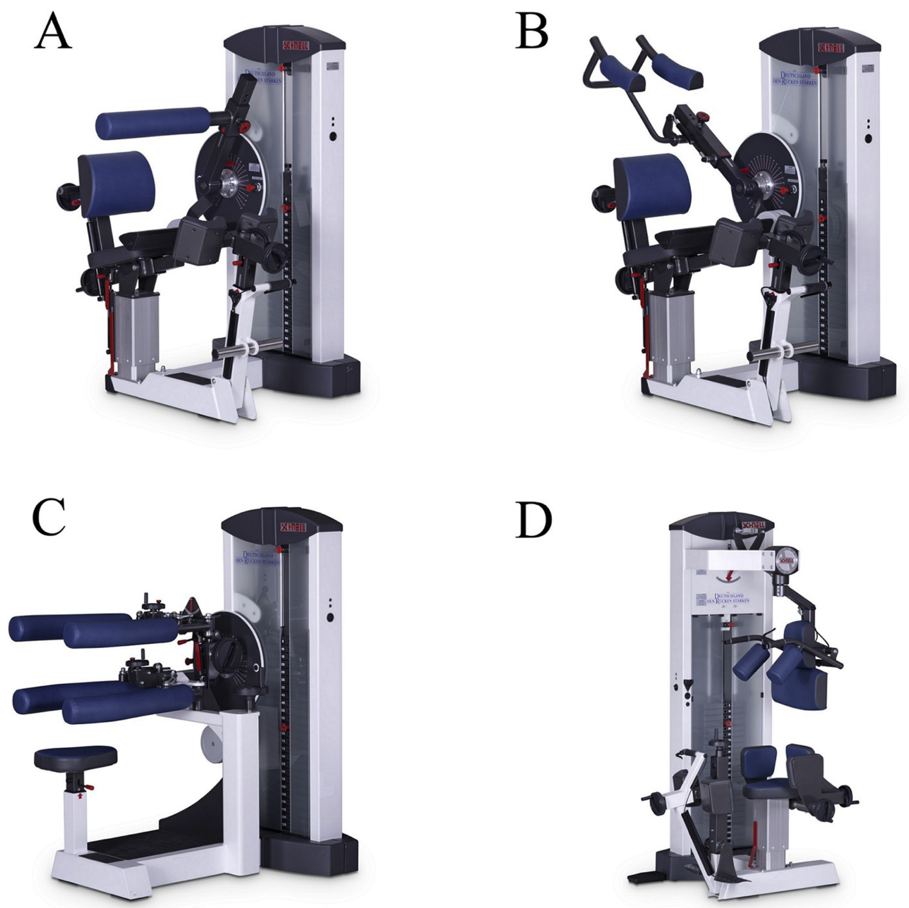

Fig. 2. Biomechanical measurement devices. (A) Analysis and training station for lumbar/thoracic extension FPZ 111; (B) Analysis and training station for lumbar/thoracic flexion FPZ 121; (C) Analysis and training station for lumbar/thoracic lateral flexion FPZ 151; (D) Analysis and training station for lumbar/thoracic rotation FPZ 131. Original pictures were provided by courtesy of *SCHNELL* Trainingsgeräte GmbH, Peutenhausen, Germany.

in the device (Fig. 2 A, B) with an assumed virtual axis of rotation at the level of L3-L4 segment with a hip angle of 75–80° and 20° flexion of the trunk.

2.5.2.2.2. Torque in lateral flexion. Patients were positioned in the measuring device (Fig. 2 C) with an assumed virtual axis of rotation at the level of L3-L4 segment with a knee and hip angle of 90°.

2.5.2.2.3. Torque in rotation. Patients were fixed in the measuring device (Fig. 2 D) allowing rotational movement only through the thoracic and lumbar spine. The knee and hip angle was 90°.

2.6. Statistical analyses

Data were statistically analyzed using SPSS, version 22.0 (IBM Corp., Armonk, NY, USA). After checking for normality by the Kolmogorov-Smirnov test with no needs for further transformations, statistical differences in the treatment between both groups were analyzed by using a 2-factorial analysis of variance (ANOVA, time × group). Due to the existing literature and knowledge concerning physiological processes of the intervention, potentially leading to increased and not decreased muscular strength and flexibility of the trunk (Pfingsten et al., 1997) one-sided alternative hypotheses were chosen, and thus, a P value of ≤ 0.10 was considered as statistically significant, expecting that the application of therapeutic heat within a MTC has only a small impact on strength and flexibility (biomechanical parameters) (Greenland et al., 2016; Wasserstein and Lazar, 2016). Additionally, the statistical power (1-ß) was calculated.

3. Results

3.1. Participants

Both treatment groups with 88 patients each, did not differ significantly in demographic and further baseline characteristics (Table 1). At t0, the mean age of all patients was 41.5 years (MTC & heat wrap group: 41.4 [SD 8.2] years; MTC group: 41.6 [SD 8.3] years). The mean duration of LBP in the MTC & heat wrap and MCT group were 7.3 (SD 7.6) and 7.1 (SD 6.9) years, respectively. The ODI score in the MTC & heat wrap and MTC group were 30.8% and 31.4%, respectively, indicating that the patients experience pain and had difficulty with sitting, lifting, standing and traveling (Fairbank and Pynsent, 2000).

3.2. Biomechanical parameters

3.2.1. Flexibility (RoM) of the trunk

In both groups, the RoM increased on average in all directions. However, there were no significant time × group interaction effects ($P \geq 0.55$). Results for both groups are shown in Table 2.

3.2.2. Strength (torque) of the trunk muscles

In both groups, the torque increased on average in all directions. There were significant time × group interaction effects concerning extension ($P = 0.09$; $1 - ß = 0.41$) as well as right ($P = 0.09$; $1 - \beta = 0.41$) and left rotation ($P = 0.08$; $1 - \beta = 0.42$). Table 3 summarizes the results for both groups.

4. Discussion

The present study addresses the effect of heat wraps additionally

Table 2
Flexibility (RoM) of the trunk [°].

	MTC & heat wrap group, n = 88			MTC group, n = 88			*P value	Power
	t0, mean (SD)	t1, mean (SD)	t0–t1 (%)	t0, mean (SD)	t1, mean (SD)	t0–t1 (%)		
Extension	52.2 (8.6)	56.5 (6.7)	8.1	50.2 (7.6)	54.8 (6.1)	9.3	0.55	0.09
Flexion	8.3 (7.8)	12.8 (7.8)	54.1	13.2 (10.9)	18.5 (10.7)	40.3	0.65	0.07
LF_{right}	31.7 (10.8)	35.7 (11.8)	13.8	33.3 (9.3)	38.5 (6.6)	14.1	0.59	0.08
LF_{left}	30.3 (10.6)	34.5 (11.3)	24.0	32.9 (8.1)	37.6 (7.0)	21.3	0.59	0.08
$Rotation_{right}$	32.2 (10.7)	41.2 (8.2)	12.5	33.5 (9.3)	40.7 (9.5)	15.7	0.65	0.07
$Rotation_{left}$	30.7 (9.9)	39.1 (8.4)	27.5	32.1 (9.1)	39.2 (9.3)	22.2	0.87	0.05

LF = Lateral flexion; SD = Standard Deviation; t0 = Pre-treatment; t1 = Post-treatment; * significant at the 0.1 level.

applied in the context of a MTC on the mobility of patients with cLBP in terms of flexibility (RoM) and muscular strength (torque) of the trunk, since they are closely related to the function of the spine, activities of daily living as well as the perceived pain (Alfuth and Cornely, 2016; Alfuth and Welsink, 2017).

Over the duration of the treatment the results show on average in both groups an improvement in flexibility and strength parameters. While no time × group interaction effects in flexibility parameters were found, there were significant effects in strength parameters (extension: $P = 0.09$, $1 - \beta = 0.41$; rotation to the right: $P = 0.09$, $1 - \beta = 0.41$; rotation to the left: $P = 0.08$, $1 - \beta = 0.42$).

Flexibility and strength are different physical abilities and differently restricted. Flexibility of the spine is predominantly limited by structural aspects (e. g., bones, discs) and the extensibility of muscles and connective tissue (Alter, 2004). Thus, additional effects of thermotherapy on flexibility cannot be expected.

In contrast, strength is depending, among others, on muscle mass and the ability to activate the available muscles fibers. Previous studies show that in LBP patients the trunk muscles are weaker, especially in extension and rotational directions (Gordon and Bloxham, 2016). High loads in extension and shearing forces in rotation are applied to the spine and the intervertebral discs (Wilke et al., 2016). For those reasons nociceptors are potentially activated and may lead to consciously or unconsciously experienced pain and muscle inhibition. This may be due to higher concentrations of inflammatory substances, such as cytokines, SP and others. These substrates can cause an inhibition of muscles, especially the muscle groups evoking high loads and pain (Barker et al., 2015; Hoheisel et al., 2012; Liang et al., 2012; Liang et al., 2013; Mense and Gerwin, 2010). The assumption that metabolism is one cause of LBP is supported by several studies, showing a positive effect of aerobic exercises on LBP (overview in Gordon and Bloxham, 2016). Due to the higher blood flow by aerobic exercises, the concentration of inflammatory substances is reduced. In this context, it is possible that the larger increase in strength parameters found in our study within the MTC & heat wrap group was caused by the higher heat driven blood flow. This enhanced blood flow may firstly lead to an enhanced metabolism, to locally reduced inflammatory metabolites and finally to an increased ability to recruit muscle fibers.

Despite the well-known analgesic effect of thermotherapy, the mode of action on pain is still unclear. The recognized underlying mechanisms include the elevation of pain thresholds, alterations of nerve conduction velocity, altered metabolism as well as a decrease in nociceptive information (Hoheisel et al., 2012; Liang et al., 2012; Liang et al., 2013; Mense and Gerwin, 2010; Michlovitz et al., 2011). Furthermore, Liang et al. (2013) recently hypothesized the causal relationship between low serum pH value and the development of back pain, which is in accordance with studies showing that in an acidified environment already slight mechanical triggers induced pain perception (Liang et al., 2013; Mense and Gerwin, 2010). Others described a doubling of the nerve fiber count in tissues with persistent inflammation as compared to acute inflammatory conditions, suggesting that nociceptive threshold values decreased due to changes in the chemical milieu (Mense and Gerwin, 2010). Thermotherapy is known to induce vasodilatation, enhanced blood circulation and increased metabolism in the treated tissue, leading to an improved oxygen and nutrition supply (Michlovitz et al., 2011). Consequently, we can assume that the application of mild heat on the lower back for several hours per day (≈40 °C over 8 h) may additionally result in reduced serum concentrations of pain-inducing mediators, inflammatory substances and neutralization of the acidic milieu, a reduced pain perception and as a result also an enhanced mobility in patients with cLBP. These mechanisms most probably lead to an increase in muscular activation and strength, which in turn further stimulates every day mobility. The normalization of the metabolism in associated tissues has furthermore been associated with a stabilization of joints as well as reduced pain scores and functional disability (Baerga-Varela and Abreu Ramos, 2006; Durall et al., 2009). These findings are further supported by a systematic review of Gordon and Bloxham (2016), showing that non-specific cLBP can be reduced by moderate aerobic exercise (heart rate 40%–60% heart rate reserve) improving the blood flow, healing processes and reducing back pain (Gordon and Bloxham, 2016). The results of the presented study substantiate this hypothesis; however, more research to clarify the exact underlying physiological mechanisms is required.

As demonstrated in further studies, MTC & heat wraps achieve positive effects in patients with chronic back pain (Borys et al., 2015; Bredow et al., 2016; Freiwald and Beermann, 2010; Guzman et al.,

Table 3
Maximum torque of the trunk musculature [$Nm/kg_{upper\ body\ mass}$].

	MTC & heat wrap group, n = 88			MTC group, n = 88			P value	Power
	t0, mean (SD)	t1, mean (SD)	t0–t1 (%)	t0, mean (SD)	t1, mean (SD)	t0–t1 (%)		
Extension	2.01 (1.78)	3.26 (2.07)	62.3	2.78 (1.34)	3.73 (1.72)	33.9	0.09*	0.41
Flexion	0.76 (1.04)	1.33 (1.31)	75.4	1.74 (0.88)	2.09 (1.04)	20.3	0.20	0.25
LF_{right}	0.98 (1.05)	1.58 (1.21)	61.8	1.38 (0.96)	1.99 (0.96)	44.6	0.50	0.10
LF_{left}	1.03 (1.13)	1.60 (1.26)	55.3	1.49 (0.92)	2.06 (0.96)	38.2	0.61	0.08
$Rotation_{right}$	0.93 (1.05)	1.57 (1.18)	68.2	1.30 (0.94)	1.80 (1.15)	38.6	0.09*	0.41
$Rotation_{left}$	0.91 (0.97)	1.53 (1.18)	67.5	1.24 (0.93)	1.68 (1.06)	35.8	0.08*	0.42

LF = Lateral flexion; SD = Standard Deviation; t0 = Pre-treatment; t1 = Post-treatment.
* Significant at the 0.1 level.

2002; Hildebrandt et al., 1997; Muller-Schwefe et al., 2017; Pfingsten et al., 1997). The results of the present study not only confirm the beneficial effects of the MTC on strength parameters in both groups, but also demonstrate an additional improvement of extension and rotation parameters due to supplemental applied heat wraps with mild heat (≈40 °C over 8 h). These findings are important, as an increase in mobility in daily activities is strongly connected with an improvement of the patient's condition, in particular with the strength of the trunk muscles. Furthermore, lumbar spine movement restrictions have been reported to strongly correlate with self-reported pain and disability scores (Monie et al., 2015). However, it must be considered that the baselines of the strength and flexibility parameters differed between both groups. Thus, it may be easier to increase the strength and flexibility from a lower compared to a higher baseline level, which may have had an impact on our findings.

4.1. Questions and future directions

In future studies, the isolated effects of a moderate heat therapy over several hours per day and their underlying physiological mechanisms with respect to cLBP should be investigated. Generally, such investigations concerning cLBP are important due to the high socio-economic importance of the underlying disease. Mild heat therapy over several hours per day might be an economical supplementary or a sole therapy alternative for the treatment of cLBP with the potential to reduce medical resource utilization.

4.2. Study limitations

The main limitation of our study is the limited sampling size and the impaired generalization of the findings to other populations suffering from cLBP, as indicated by our generally low statistical power levels. However, it should be considered that our study is the first to investigate in a clinically standardized setting the effects of a heat wrap therapy additionally performed to an MTC on flexibility and strength in cLBP patients. Further studies examining the effects of a heat wrap therapy in other patient populations are needed in order to make a general statement on the impact of this therapy form on cLBP. An additional limitation of our study is that our study findings concerning the biomechanical parameters did not allow conclusions concerning their clinical relevance (e.g. physical and/or daily activities). However, it has already been shown in patients with cLBP that flexibility and muscular strength of the trunk are related to the function of the spine, activities of daily living as well as the perceived pain (Alfuth and Cornely, 2016; Alfuth and Welsink, 2017; Mayer et al., 2005).

5. Conclusions

The supplemental use of heat wraps in patients with cLBP, receiving a multimodal treatment over 12 weeks, provided a benefit in muscular strength of the trunk. Thus, the implementation of an additional heat wrap therapy in daily clinical practice can be recommended. While the implementation of heat wraps can be recommended, further studies to clarify the clinical meaningfulness of our findings are warranted.

Conflicts of interest statement

Conflicts of interest: none.

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Ethical approval

This study was approved by the Ethics Committee of the University of Wuppertal, Wuppertal, Germany (approved by written communication, October 19, 2011).

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