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Physical therapy and active exercises – An adequate treatment for prevention of late whiplash syndrome? Randomized controlled trial in 200 patients

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Abstract

The aim of this study was to compare the effect of a physical therapy regimen including active exercises with the current standard treatment on reduction of pain 6 weeks and 6 months after whiplash injury caused by motor vehicle collision. Two hundred patients were enrolled in a prospective randomized controlled trial. In the standard group, treatment consisted of immobilization with a soft collar over 7 days. In the physical therapy group, patients were scheduled for 10 physical therapy appointments including active exercises within 14 days after enrollment. Pain intensity was rated by all patients daily during the first week, the sixth week, and 6 months after recruitment, using a numeric rating scale (0–10). Data analyses were performed by comparing the mean (over 1 week) pain scores between the two different treatment groups. Ninety-seven patients were randomly assigned to the standard treatment group and 103 to the physical therapy group. During the first week, there was no significant difference in mean pain intensity between the standard treatment group (4.76 ± 2.15) and the physical therapy group (4.36 ± 2.14). However, after 6 weeks, mean pain intensity was significantly ($p = 0.002$) lower in the physical therapy group (1.49 ± 2.26 versus 2.7 ± 2.78). Similarly, after 6 months, significantly ($p < 0.001$) less pain was reported in the physical therapy group (1.17 ± 2.13) than the standard treatment group (2.33 ± 2.56). We conclude that a physical therapy regimen which includes active exercises is superior in reducing pain 6 weeks and 6 months after whiplash injury compared to the current standard treatment with a soft collar.

Keywords: Cervical spine; Conservative treatment; Physical therapy; Randomized controlled trial; Soft collar; Whiplash injury

1. Introduction

Whiplash-associated disorders caused by motor vehicle accident can be graded according to the Quebec Task Force classification, where grades I and II correspond to mild trauma (Spitzer et al., 1995). Micro-lesions of ligamentous and muscular structures of the cervical spine are thought to cause the most common symptoms, which include neck pain, headache, and shoulder pain (Örtengren et al., 1996; Eichberger et al., 2000; Walz and Muser, 2000). Immobilization of the cervical spine with a soft collar, as well as treatment with nonsteroidal anti-inflammatory drugs (NSAID), is common practice in patients suffering from whiplash injury (Spitzer et al., 1995; Peeters et al., 2001). This treatment regimen is based on the rationale that the pathology underlying the complaints involves distortion of zygapophyseal joints and, in analogy to the treatment of distortion to other joints (e.g., ankle joint), immobilization seems indicated (Giebel, 1966; Gibson, 1974). However,

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previous surveys dealing with long-term results show that 30–66% of affected patients report persisting symptoms for longer than 6 months after immobilization with a soft collar, suggesting that immobilization may not be applicable to patients with whiplash injury in the acute phase (Norris and Watt, 1983; Hildingsson and Toolanen, 1990; Radanov et al., 1993).

Recently, a systematic review by Verhagen and colleagues (2004) indicated that active interventions (e.g., exercises) may improve the prognosis of posttraumatic impairment compared to passive treatment (e.g., soft collar). Unfortunately, the trials included in this review had methodological deficiencies that do not allow a final conclusion regarding the putative superiority of active regimes including exercises (Verhagen et al., 2004). Therefore, the aim of the present trial was to investigate the effects of a physical therapy regimen (including active exercises), started within 48 h after suffering whiplash injury, on reducing pain and disability 6 weeks and 6 months after injury, when compared to the current standard procedure, employing immobilization with a soft collar.

2. Methods

2.1. Study population

Patients with whiplash injury grades I and II, according to the Quebec Task Force classification (Spitzer et al., 1995), were enrolled into the trial between August 1997 and May 2000. The patients were presented to the trauma surgery outpatient department of the University Hospital of Marburg (Germany) within 48 h after injury. Eligibility and exclusion criteria are listed in Table 1. To describe the study population, the following data were documented at baseline (t0): age, gender, accident-related characteristics (type of collision, position of the seat, and seatbelt use), and the expectation of financial compensation for pain and suffering.

2.2. Study protocol

The trial was approved by the local Ethics Committee of the Philipps-University Marburg. The trial was designed as an unblinded, concealed allocation, randomized controlled trial with two groups (physical therapy group versus standard treatment group). After recruitment and informed consent, each patient was randomized to a group by drawing one of two lots in similar, sealed envelopes from a jar. The probability for allocation in one of the two groups was 50% for each participant.

2.3. Treatment

In the standard treatment group, a soft collar (Ruthner Company, Neckargemünd, Germany) had to be worn continuously after the injury during the first seven days in addition to oral medication with diclofenac (50 mg three times daily) and ranitidine (150 mg twice daily). Thereafter, there was no further specific treatment.

In the physical therapy group, patients were appointed to 10 sessions of physical therapy and active exercises within the first 14 days after whiplash injury. Physical therapy included application of heat to the neck for 5 min according to the principles of Schnizer and Schöps (1995), lymph drainage for 10 min according to the principles of Vodder (1983), massage for 10 min according to the principles of Zahnd and Mühlemann (1996), and 10 min active exercises with an elastic resistance exercise band (Thera-Band®, Dr. Brügger-Institute, Zurich, Switzerland) according to the Thera-Band-exercises for neck pain and shoulder pain described by Rock (1993).

Table 1
Eligibility and exclusion criteria

Eligibility criteria	Exclusion criteria
• Diagnosed whiplash injury (grades I and II according to the Quebe Task Force classification) in patients caused by motor vehicle accident	• Patients with a history of whiplash injury longer than 48 h prior to potential inclusion into the trial • Patients younger than 18 years • Patients older than 70 years • Patients with a history of chronic or recurrent pain of any etiology within 6 months prior to accident requiring medical treatment • Patients suffering from additional accident-related and clinically (or radiologically) proven head, neck, thorax or other injury • Patients with diseases or conditions representing contraindications for one of the scheduled treatment procedures • Patients with a permanent residence outside a 50 km (approximately 30 miles) radius from Marburg • Pregnancy • Patients presenting with a second accident resulting in injuries of head, neck, or thorax while participating in the trial • Patients undergoing surgery of head, neck, or thorax while participating in the trial • Patients (physical therapy group) treated by nondesignated physiotherapists • Patients with modification of treatment due to new findings and diagnoses • Patients who refused to participate

The exercises also had to be performed at home during the first 14 days after injury for 20 min daily. Diclofenac and ranitidine were administered according to the procedure in the standard treatment group. Use of a soft collar (Ruthner Company, Neckargemünd, Germany) was allowed, on demand by the patient, for the first 2 days after injury.

2.4. Clinical assessment and follow-up

Times of clinical assessment and follow-up were: first presentation at enrollment into the study (t0), 7 days after the first admission (t1), 6 weeks after the first admission (t2), and 6 months after the first admission (t3).

2.5. Primary outcome measures

The primary outcome parameters were pain intensity and disability 6 weeks and 6 months after whiplash injury, rated by the patients. For this purpose, the patients were asked to keep pain diaries (PD) during the first week after injury (PD1), 1 week prior to follow-up at 6 weeks (PD2), and 6 months (PD3) after the initial presentation. The intensity of pain and disability were rated daily by means of an 11-point (0–10) numeric rating scale (NRS) (Jensen et al., 1989). The value "0" corresponds to no pain or disability, whereas a value of "10" is maximum pain and disability imaginable.

2.6. Secondary outcome measures

Secondary outcome parameters were as follows: mean number of days with oral medication, the period of immobilization with the soft collar, the physical therapy and active exercises schedule during the first week after injury, the localization of the injury-associated pain disorder at t0, t2, and t3, and the proportion of patients with no residual pain at t2 and t3.

For localization of the injury-associated pain disorder, patients were asked to mark the affected regions on standardized tables showing dermatomes. Lack of pain was defined as a mean pain intensity score <1 (Söderlund et al., 2000).

2.7. Statistics

Prior to starting the study, a sample size of 140 patients was calculated with G*Power (Erdfelder et al., 1996) using $\alpha = 5\%$, $\beta = 10\%$, and an anticipated 30% benefit of one therapy compared to the other in the primary outcome measures (pain intensity and disability). Assuming a loss to follow-up of 30%, a minimum initial sample size of 200 participants was chosen.

Based on the hypothesis that active treatment in the physical therapy group would improve outcome, data analyses were carried out by comparing the mean values of pain intensity and disability obtained from PD1, PD2, and PD3. After testing for normal distribution with the Kolmogorov–Smirnov test, differences between the groups at t1 were analyzed using the two-sample *t*-test. However, since the basic assumption of normal distribution was violated at t2 and t3, as shown by the Kolmogorov–Smirnov test, we used the more appropriate nonparametric Mann–Whitney *U*-test. An intention-to-treat analysis (last observation carried forward) was realized in addition to the per-protocol analysis (Hollis and Campbell, 1999). Differences between the groups in the proportion of patients without pain at t2 and t3 were analyzed using the χ^2 test (Fisher's exact test).

Before the onset of the trial, the level of significance was set at $p \leqslant 0.05$. For the primary outcome measures and baseline values, significant differences were defined by one-sided calculation; for the proportion of patients without pain, a two-sided significance analysis was performed.

The data analyses were performed blind to treatment allocation by a statistician of the Department of Medical Psychology, University School of Medicine, Marburg. Calculation of statistical tests and descriptive evaluations were carried out using SPSS software for Windows (Release 9.0.1, Standard Version). All data are presented as means ± standard deviation.

3. Results

3.1. Selection of the study population

Details of patient recruitment, loss to follow-up, and excluded participants for the per-protocol analysis are shown in Fig. 1. Two hundred out of 653 consecutive eligible patients were included in the study. Two hundred and sixty-seven patients were not included due to existing exclusion criteria, and 186 patients declined to participate in the study. One hundred and three patients out of the 200 study patients were randomly allocated to the physical therapy group. Ninety-two of these patients were included in the intention-to-treat analysis and the per-protocol analysis concerning the baseline values of the primary outcome measures pain intensity and disability. Seven patients were lost to follow-up after t0, and four patients had not completed their pain diaries at t1. Ninety-seven patients were randomly assigned to the standard treatment group. Eighty-one of these patients were included in the per-protocol analysis concerning the baseline values of the primary outcome measures and the intention-to-treat analysis. Fourteen patients were lost to follow-up after t0. Two patients had to be excluded because of missing pain diaries at t1.

3.2. Subject baseline characteristics and clinical assessment

There were no differences between the groups regarding demographic and accident-associated characteristics, as well as expectation of compensation for pain and suffering (Table 2). The mean time interval between suffering whiplash injury and enrollment into the study population was 8.5 ± 9.3 h. The time period between injury and reassessment during follow-up was 7.3 ± 2.7 days for t1, 49.1 ± 10.4 days for t2, and 191.6 ± 21.9 days for t3, with no differences between the groups.

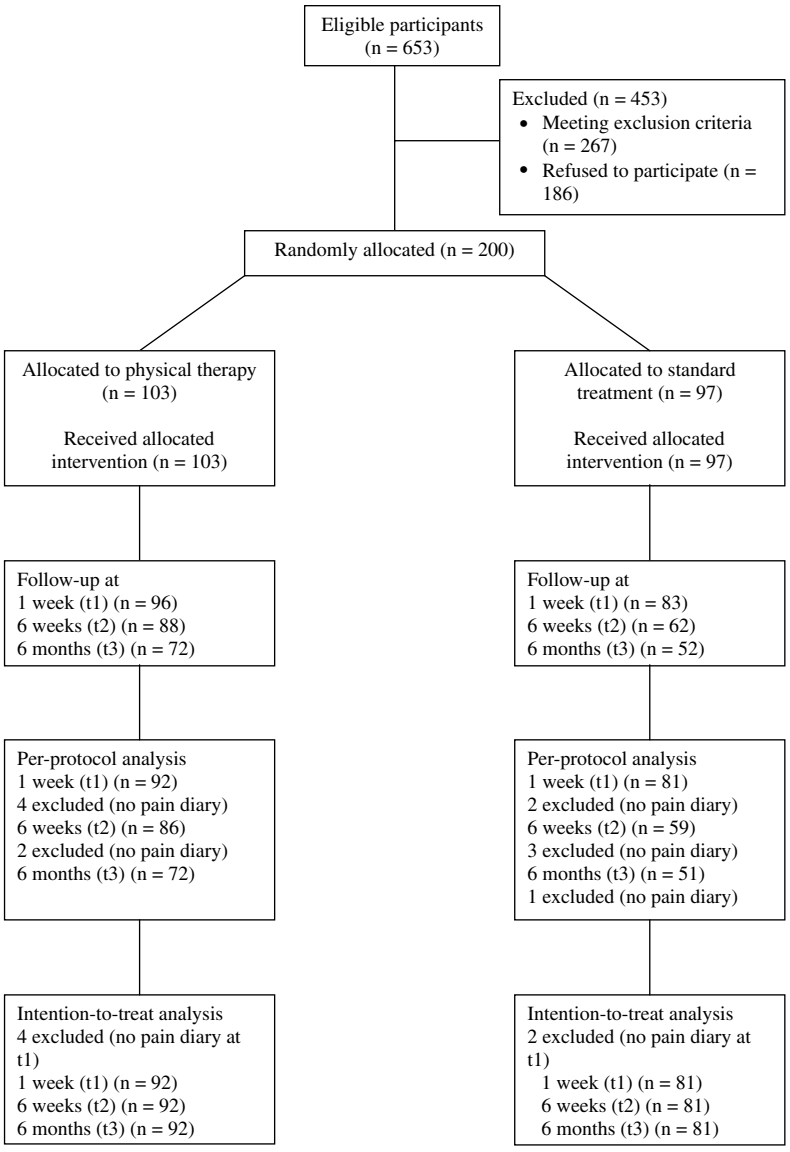

Fig. 1. Selection of the study population.

3.3. Primary outcome measures

As indicated in Table 3a, there were no significant differences in pain intensity or disability values between the groups in the first week. Mean pain intensity was 4.76 ± 2.15 in the standard treatment group and 4.36 ± 2.14 in the physical therapy group ($p = 0.22$), and the mean disability values were 4.77 ± 1.97 versus 4.28 ± 2.09 ($p = 0.11$). However, per-protocol and intention-to-treat analyses revealed significant group differences (in favor of the physical therapy group) both in pain intensity and disability at 6 weeks (PD2) and 6 months (PD3) after injury (Tables 3a and 3b).

The per-protocol analysis of PD2 at t2 (6 weeks) showed that mean pain intensity in the physical therapy group (1.04 ± 1.81) was significantly lower than in the standard treatment group (1.60 ± 2.15, $p = 0.04$), and mean disability was likewise significantly reduced (0.92 ± 1.70 versus 1.56 ± 2.22, $p = 0.04$). At t3 (6 months), mean pain intensity and mean disability values (0.52 ± 1.13 and 0.43 ± 0.92, respectively) were also significantly lower than in the standard treatment group (0.99 ± 1.36 ($p = 0.02$) and 0.79 ± 1.08 ($p = 0.04$), respectively).

The results of the intention-to-treat analysis were consistent with the per-protocol analysis. At t2, mean pain intensity was lower in the physical therapy group (1.49 ± 2.26) than in the standard treatment group (2.70 ± 2.78, $p = 0.002$), and mean disability was 1.31 ± 2.19 versus 2.49 ± 2.69 ($p = 0.002$) in the physical therapy and standard treatment group, respectively. At t3, mean pain intensity was also lower in the physical therapy group (1.17 ± 2.13 versus 2.33 ± 2.56,

Table 2
Subject baseline characteristics (t0)

Characteristics	Standard treatment ($n = 97$)	Physical therapy ($n = 103$)
Demography		
Mean age in years	28.3 ± 8.9	30.1 ± 10.3
Gender (female/male)	59 (60.8%)/38 (39.1%)	64 (62.1%)/39 (37.8%)
Collision type		
Rear	38 (39.1%)	42 (40.7%)
Frontal	29 (29.8%)	30 (29.1%)
Lateral	10 (10.3%)	12 (11.6%)
Roll-over	10 (10.3%)	8 (7.7%)
Multiple impacts	10 (10.3%)	10 (9.7%)
Position in vehicle		
Driver	79 (81.4%)	84 (81.6%)
Front passenger	15 (15.4%)	16 (15.5%)
Rear passenger	3 (3.1%)	3 (2.9%)
Seatbelt use		
Data missing	1 (1%)	3 (2.9%)
Yes	94 (96.9%)	95 (92.2%)
No	2 (2.1%)	5 (4.8%)
Claim status		
Data missing	0 (0%)	1 (0.9%)
Yes	41 (42.2%)	51 (49.5%)
No	56 (57.8%)	51 (49.5%)

n, sample size; ±, standard deviation.

$p < 0.001$), as was the case for mean disability (1.05 ± 1.99 versus 2.03 ± 2.39, $p < 0.001$).

3.4. Proportion of patients without pain at t2 and t3

As can be seen in Table 4, more patients reported no pain 6 weeks after t0 in the physical therapy group (67.4%) compared to the standard treatment group (54.2%, $p = 0.12$). Significantly more patients were also free of pain 6 months after t0 in the physical therapy group (81.9%) compared to the standard treatment group (62.7%, $p = 0.02$).

3.5. Clinical disorders

Although there were no differences between the groups at t0, differences regarding the incidence of trauma-associated disturbances became evident after 6 weeks (t2) and 6 months (t3). This was particularly the case for the most common presenting symptoms (neck pain, headache, and shoulder pain) (Tables 5a, 5b, and 5c). At t2, 28.4% of the patients in the physical therapy group reported neck pain (compared to 45.2% in the standard treatment group), 13.6% complained of headache (compared to 27.4%), and 15.9% reported shoulder pain (compared to 33.9%). Similar results were obtained 6 months after the injury. Neck pain was reported by 20.8% of the patients in the physical therapy group, compared to 38.4% in the standard treatment group. Furthermore, headache was documented by only 4.1% of the patients in the physical therapy group, compared to 17.3% of the patients in the standard treatment group. In addition, less shoulder pain (6.9%) was reported by patients in the physical therapy group compared to the standard treatment group (23%).

Table 3a
Per-protocol analysis: pain intensity and disability within the first week (PD1), the sixth week (PD2), and 6 months (PD3) after whiplash injury

Outcome variable	Standard treatment	Physical therapy	Statistics	*p*-value
Pain				
Pain PD1	4.76 ± 2.15 ($n = 81$)	4.36 ± 2.14 ($n = 92$)	*t*-test $t = 1.22$ ($n = 173$)	0.22
Pain PD2	1.60 ± 2.15 ($n = 59$)	1.04 ± 1.81 ($n = 86$)	Mann–Whitney $Z = -1.67$ ($n = 145$)	0.04
Pain PD3	0.99 ± 1.36 ($n = 51$)	0.52 ± 1.13 ($n = 72$)	Mann–Whitney $Z = -1.97$ ($n = 123$)	0.02
Disability				
Disability PD1	4.77 ± 1.97 ($n = 81$)	4.28 ± 2.09 ($n = 92$)	*t*-test $t = 1.56$ ($n = 173$)	0.11
Disability PD2	1.56 ± 2.22 ($n = 59$)	0.92 ± 1.70 ($n = 86$)	Mann–Whitney $Z = -1.72$ ($n = 145$)	0.04
Disability PD3	0.79 ± 1.08 ($n = 51$)	0.43 ± 0.92 ($n = 72$)	Mann–Whitney $Z = -1.74$ ($n = 123$)	0.04

n, number of patients; PD1, first pain diary (course of disease protocol within 1 week after whiplash injury); PD2, second pain diary (course of disease protocol within 6 weeks after whiplash injury); PD3, third pain diary (course of disease protocol within 6 months after whiplash injury); *t*, test statistic for Student's *t*-test's impaired samples; *Z*, test statistic for Mann–Whitney *U*-test; ±, standard deviation.

Table 3b
Intention-to-treat analysis: pain intensity and disability within the sixth week (PD2) and 6 months (PD3) after whiplash injury

Outcome variable	Standard treatment ($n = 81$)	Physical therapy ($n = 92$)	Statistics	*p*-value
Pain				
Pain PD2	2.70 ± 2.78	1.49 ± 2.26	Mann–Whitney $Z = -3.11$	0.002
Pain PD3	2.33 ± 2.56	1.17 ± 2.13	Mann–Whitney $Z = -3.70$	<0.001
Disability				
Disability PD2	2.49 ± 2.69	1.31 ± 2.19	Mann–Whitney $Z = -3.16$	0.002
Disability PD3	2.03 ± 2.39	1.05 ± 1.99	Mann–Whitney $Z = -3.41$	<0.001

n, number of patients; PD2, second pain diary (course of disease protocol within 6 weeks after whiplash injury); PD3, third pain diary (course of disease protocol within 6 months after whiplash injury); *t*, test statistic for Student's *t*-test's impaired samples; *Z*, test statistic for Mann–Whitney *U*-test; ±, standard deviation.

Table 4
Proportion of patients without pain (per protocol)

	Standard treatment	Physical therapy	Statistics	p-value
Number of patients with mean rating of pain <1 at t2 (PD2)	54.2% ($n = 32/59$)	67.4% ($n = 58/86$)	χ^2 (Fisher's test)	0.12
Number of patients with mean rating of pain <1 at t3 (PD3)	62.7% ($n = 32/51$)	81.9% ($n = 59/72$)	χ^2 (Fisher's test)	0.02

n, number of patients; PD2, second pain diary (course of disease protocol within 6 weeks after whiplash injury); PD3, third pain diary (course of disease protocol within 6 months after whiplash injury).

3.6. Patient compliance

Patients took their prescribed medication for an average period of 4.4 ± 2.3 days in the standard treatment group, and 3.5 ± 2.9 days in the physical therapy group (Table 6). Analyses of the pain diaries revealed that patients in the standard treatment group wore a soft collar over 5.6 ± 1.5 days for 18 ± 7.1 h/day, whereas patients in the physical therapy group wore a collar over 2.6 ± 2.4 days for 3.8 ± 5.2 h/day. Ninety-one patients in the physical therapy group had appointments with one of the selected physiotherapists for physical therapy and active exercises on a mean of 2.9 ± 1.4 days within the first week after injury. In addition, 68 of the 91 patients reported to perform active exercises at home, 2.8 ± 2.2 days per week for an average duration of 8 ± 7 min/day.

4. Discussion

The results of this study clearly indicate an advantage of active exercises over immobilization in the treatment of whiplash injury. This finding is in line with previous studies focusing mainly on short-term outcomes (Mealy et al., 1986; McKinney, 1989; Bonk et al., 2000), as well as two recently published randomized controlled trials (Rosenfeld et al., 2003; Crawford et al., 2004) showing benefits of physical therapy and active exercises on long-term functional recovery. However, it should be noted that, independent of active exercise regimens, it has been reported that simply advising a patient to "act as usual" (continue usual daily activities) and refrain from sick leave improves outcome after 6 months compared to the combination of immobilization with a soft collar and 14 days of sick leave (Borchgrevink et al., 1998). Thus, the Quebec Task Force recommendation for active therapy, promotion of usual activities, and avoidance of collars (Spitzer et al., 1995) is supported by the results of the present study and the recent literature.

In principle, there are a number of potential biases that might have affected the internal validity of the present study, which are addressed below. It may be questioned whether the somewhat unusual randomization procedure (drawing lots) used in our study was fool-proof. However, the correctness of the procedure was assured by the fact that the randomization was performed by only one person (the last author

Table 5a
Presentation of symptoms at baseline (t0)

Symptoms	Study population $n = 200$ (100%)	Standard treatment $n = 97$ (100%)	Physical therapy $n = 103$ (100%)
Neck pain	193 (96.5)	93 (95.9)	100 (97.1)
Headache	120 (60)	59 (60.8)	61 (59.2)
Shoulder pain	98 (49)	53 (54.6)	45 (43.7)
Back pain	34 (17)	18 (18.6)	16 (15.6)
Limb pain	9 (4.5)	8 (8.2)	1 (0.9)
Paresthesia	20 (10)	12 (12.4)	8 (7.8)
Visual disturbance	36 (18)	15 (15.5)	21 (20.4)
Tinnitus	10 (5)	7 (7.2)	3 (2.9)
Dizziness	68 (34)	33 (34)	35 (34)

n, sample size.

Table 5b
Presentation of symptoms after 6 weeks (t2)

Symptoms	Study participants $n = 150$ (100%)	Standard treatment $n = 62$ (100%)	Physical therapy $n = 88$ (100%)
Neck pain	53 (35.3)	28 (45.2)	25 (28.4)
Headache	29 (19.3)	17 (27.4)	12 (13.6)
Shoulder pain	35 (23.3)	21 (33.9)	14 (15.9)
Back pain	12 (8)	7 (11.3)	5 (5.7)
Limb pain	6 (4)	4 (6.5)	2 (2.3)
Paresthesia	8 (5.3)	4 (6.5)	4 (4.5)
Visual disturbance	8 (5.3)	5 (8.1)	3 (3.4)
Tinnitus	4 (2.7)	3 (4.8)	1 (1.1)
Dizziness	11 (7.3)	5 (8.1)	6 (6.8)

n, sample size.

Table 5c
Presentation of symptoms after 6 months (t3)

Symptoms	Study participants $n = 124$ (100%)	Standard treatment $n = 52$ (100%)	Physical therapy $n = 72$ (100%)
Neck pain	35 (28.2)	20 (38.4)	15 (20.8)
Headache	12 (9.6)	9 (17.3)	3 (4.1)
Shoulder pain	17 (13.7)	12 (23)	5 (6.9)
Back pain	2 (1.6)	2 (3.8)	0 (0)
Limb pain	2 (1.6)	0 (0)	2 (2.7)
Paresthesia	4 (3.2)	1 (1.9)	3 (4.1)
Visual disturbance	2 (1.6)	2 (3.8)	0 (0)
Tinnitus	0 (0)	0 (0)	0 (0)
Dizziness	2 (1.6)	1 (1.9)	1 (1.3)

n, sample size.

Table 6
Self-reported compliance within the first week after whiplash injury

Treatment compliance	Standard treatment	Physical therapy
Mean number of days with oral medication	4.4 ± 2.3 ($n = 81$)	3.5 ± 2.9 ($n = 92$)
Mean number of days wearing a soft collar	5.6 ± 1.5 ($n = 81$)	2.6 ± 2.4 ($n = 92$)
Mean time (h) per day wearing a soft collar	18 ± 7.1 ($n = 81$)	3.8 ± 5.2 ($n = 92$)
Mean number of days with appointments at a physiotherapist	No physical therapy	2.9 ± 1.4 ($n = 91$)
Mean number of days with active exercises at home	No active exercises	2.8 ± 2.2 ($n = 68$)
Mean duration (min/day) of active exercises at home when performed	No active exercises	8 ± 7 ($n = 68$)

n, sample size; $\pm$, standard deviation.

M.S.), who was not involved in the subsequent clinical examinations. Furthermore, since the two study groups did not differ in terms of demographic and accident-associated characteristics, the expectation of compensation for pain and suffering at baseline, and the initial intensity of pain and disability, we may assume that the randomization procedure was appropriate. In addition, differential drop-out-rates between the groups might have biased the study results. We accounted for this potential bias by using intention-to-treat analysis for the primary outcome measures. Moreover, given that drop-outs did not differ from those who remained in terms of baseline subject characteristics and the initial intensity of pain and disability (Schnabel et al., 2001), we assume that the generalizability of our results is not biased by selection effects. A third issue, the intensity of patient–therapist contact, was not controlled for in our study. In the physical therapy group, therapists spent more time with the patients than in the standard treatment (collar) group. This might have had an additional positive influence on pain and disability in physical therapy patients. Also, different drop-out-rates between the groups might be due to this difference in patient–therapist contact.

Demographic and crash-related characteristics found in our sample were comparable to those of other epidemiological studies conducted in Germany, Norway, and Canada (Spitzer et al., 1995; Borchgrevink et al., 1996; Richter et al., 1999). Also, the prevalence of symptoms in the acute phase of whiplash injury observed in our sample was compatible with reports in the literature (Norris and Watt, 1983; Hildingsson and Toolanen, 1990; Radanov et al., 1993; Richter et al., 2004). Thus, we may assume that our sample is representative for patients suffering whiplash in a western industrial country.

Finally, the underlying mechanisms of the therapeutic effects of an active physical therapy regime should be addressed. Affected patients typically adopt abnormal patterns of muscle activity, characterized by hyperlordosis and malposition of the cervical spine, to relieve and avoid pain (McKinney, 1994; Nederhand et al., 2003). If this posture persists over a prolonged period, pain can arise from the unphysiological burden on muscles and joints (Basler, 1994; McKinney, 1994). Studies using local anesthetic blocks have identified the cervical zygapophyseal (facet) joints as important anatomical sources of pain following whiplash injury (Barnsley et al., 1993; Lord et al., 1996), and various experimental and computational models have demonstrated marked facet joint ligament elongations during whiplash (Stemper et al., 2005a,b). We speculate that a physical therapy regime including active exercises with an elastic exercise band avoids unphysiological postures underlying chronicity, and facilitates restoration of normal cervical spine function. Future trials should aim to optimize the physical therapy regimes to improve the prognosis after whiplash injury.

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