Sensorimotor and Body Perception Assessments of Chronic Nonspecific Low Back Pain: A Case-Control Study

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Research article

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Abstract

Background: Low back pain is one of the most common musculoskeletal disorders. It leads to major costs in health care systems and causes significant personal and social burdens. Current research focuses on the processes of the central nervous system such as cortical changes in pain perception to discover new and more efficient ways to treat chronic low back pain (CLBP). Several clinical tests have been suggested that might correlate with altered cortical representation. These include back-photo assessment (BPA), movement control tests (MCI) and two-point discrimination thresholds (TPD).

Objective: The aim of this study was to determine whether BPA, MCI and TPD tests can discriminate between CLBP patients with altered body perception and healthy controls.

Design: A case-control study matched by gender and age.

Methods: Using MCI, BPA and TPD tests on the lower back, thirty patients with CLBP and thirty healthy controls were investigated at one point in time. Participants were also required to complete three questionnaires: the 'Fear Avoidance Belief Questionnaire', the 'Hospital Anxiety and Depression Scale' and the 'Fremantle Back Awareness Questionnaire'. Correlations among the main covariates and odds ratios for group differences were calculated.

Results: The MCI showed a statistically significant odds ratio for the presence of CLBP of 0.65 ($p < 0.05$), whereas TPD and BPA did not determine differences between the groups.

Conclusion: The movement control test was found to be the only suitable test to discriminate CLBP patients from healthy controls.

Trial registration: The study was approved by the Swiss Ethical Commission Northwest and Central Switzerland (EKNZ) and registered at 21.8.2015, reference number 2015-243.

Introduction

Low Back Pain (LBP) is one of the most common musculoskeletal disorders and causes significant personal and social burdens (1). LBP has a lifetime prevalence of 70–85% (2). Although the prognosis for recovery from acute LBP is favorable, recurrence is common, with 33% reporting a renewed onset of LBP within one year (2). Furthermore, 42–75% continue to experience LBP 12 months after pain onset (3). When LBP becomes persistent it creates major costs in health care systems (4). Currently, 85% of LBP cases are classified as nonspecific LBP, meaning that no specific structural causes can solely explain the symptoms (5). Strategies to manage nonspecific LBP include both conservative and invasive treatments. Outcomes for unimodal treatments are poor (1). Thus, tailored management strategies for LBP treatment remain a major challenge (6–8).

Chronic LBP is defined pain longer than 3 months (9). Recent neuroimaging studies have demonstrated neurochemical, structural and functional alterations in the primary sensory cortex in these patients (5, 7, 8). This supports the emerging evidence that central nervous system (CNS) processes also contribute to CLBP (7, 10). CLBP may increase sensitivity in the spinal cord and the cortex, leading to the amplification of peripheral inputs and, possibly, causing widespread hyperalgesia. Furthermore, the inhibitory mechanisms of the CNS demonstrate reduced functionality in CLBP patients (8, 10–12). These factors may contribute to the previously identified changes in cortical representations and body perceptions, as well as reduced grey matter volume in the somatosensory cortex (8, 10–12). As such, simple clinical tests to assess the sensory motor system and develop tailored management strategies for patients in a chronic pain state, have become increasingly important to physicians.

Several clinical assessments are thought to be correlates of changes in sensory and motor system and body perception on a cortical level. Firstly, two-point discrimination (TPD) examines the tactile acuity of LBP patients. Patients with LBP demonstrate increased TPD values compared to healthy controls (13, 14). TPD was proposed as a surrogate measure of changes in the somatosensory cortex (S1) (11, 15–17). Secondly, CLBP patients present with reduced perception of their spine (18), affecting movement that is controlled by the central nervous system (12, 19). Tests of movement control impairment (MCI) are common in identifying possible deficits of motor control (20, 21) and can discriminate between LBP patients and healthy controls (12, 18–21). MCI and TPD are associated (17) Thirdly, visual approaches, such as back-photo assessment (BPA), can test body perception and perceived body image. BPA uses photos to modify the width of the person's lower back. People are asked to identify the original, unmodified photo of their back from the various modified versions. This method has already been used on limbs in patients with complex regional pain syndrome (CRPS) is thought to present changes in S1(22). However, to date, BPA has not been validated for CLBP patients. Recent evidence has demonstrated an altered body image perception in

patients with CLBP when asked to complete a partial drawing of their back silhouette. CLBP patients were unable to clearly outline their trunk in the painful area (23).

The aim of this study was to determine whether BPA, MCI and TPD tests which are thought to present somatosensory changes, could discriminate between CLBP patients with altered body perception and healthy controls.

Methods

Participants

A convenience sample of 60 participants was collected from three outpatient physiotherapy clinics in Central Switzerland. Thirty were patients with nonspecific CLBP, 30 were controls and the groups were matched by gender and age. Inclusion criteria were: 1) age between 18 and 83 years; 2) proficient in written and spoken German language; 3) no current pregnancy or pregnancy in the past 6 months; 4) at least four points on the Roland Morris Disability Questionnaire (RMDQ) indicating at least moderate disability because of LBP; and 5) the presence of CLBP as defined by at least three months of unilateral or bilateral LBP. CLBP participant exclusions were: 1) clinical bedside signs of nerve root pain or evidence of specific spinal pathology (e.g. malignancy, fracture, infection, inflammatory join or bone disease and 2) surgery on the lower back in the past six months. Healthy controls were excluded if they had any history of LBP in the past six months or a period of LBP of more than one month in the past. The Swiss Ethical Commission of Northwest and Central Switzerland (EKNZ) ethically approved the study (reference number 2015 – 243). All participants gave their informed written consent prior to study start and all procedures conformed to the declaration of Helsinki.

Design

Case-control study design.

Assessments

Examiners were blinded to the participants' condition and recorded the results of the BPA, TPD and MCI tests.

BPA is a graphic approach to exploring distorted body image. It has previously been used to assess a population with complex regional pain syndrome (CRPS) (22). In this study, the lumbar vertebra four was marked on the skin and a photo taken in a standing position from the middle part of the gluteal area to the occipital part of the skull to depict the participant's back. The photo was then modified at level L4, using the GNU Image Manipulation Program (GIMP 2.8.14 for OS X) in steps of 3% enlargement and shrinkage. The maximal limit was set at ±12%. This resulted in eight modified photos plus one original photo for each participant. The photos were allocated a number from 1 to 9 in order of the modification extent. Numbers 1 to 4 were allocated to the shrunken photos with 1 representing picture shrunk by -12% (Fig. 1). Number 5 was given to the original, unmodified photo and numbers 6 to 9 were allocated to the enlarged photos, with 9 representing the picture enlarged by 12%. The photos were then arranged on a piece of paper in a randomized sequence. The same sequence was used for all participants. The participants were asked to identify the original photo of their back. The number of deviating steps between chosen and neutral picture, no matter if to the shrunken or enlarged direction, was noted as BPA outcome with a value ranging from 0–4.

TPD is a reliable intra-rater measure to detect altered tactile acuity (24). TPD measurements were taken using a plastic caliper, according to an established protocol (15, 17, 25) (Fig. 2.). The participant lay prone and unable to see the caliper. An examiner measured both horizontal and vertical TPD bilaterally on the participant's lower back at level L4 (24). The caliper tip distance ranged from 100 mm to 5 mm, and the test started with the maximum spread. For every correct detection, the spread distance was decreased by 10 mm. Conversely, for every incorrect detection, the spread distance was increased by 5 mm. This procedure was repeated three times in descending and ascending order and the average of the smallest distance between the caliper tips at which the participant was still able to discriminate between the two separate points was recorded as the TPD value (17).

MCI of the lumbar spine was evaluated using a test battery of six tests designed to test the movement control of the back (Fig. 3.). The MCI test battery has been shown to be a reliable tool to detect impaired lumbopelvic control (20, 21, 26). Firstly, the examiner explained the task and the participants were instructed to perform specific movements. Secondly, the examiner provided verbal corrections if the movement was performed incorrectly. Finally, if the movement was performed incorrectly at the second try, the examiner demonstrated the correct movement. A positive test result was recorded if a participant was still unable to perform the correct movement following the second demonstration. Examiners rated a correctly performed movement as a negative test result. The test results were scored on a range from 0 (all tests performed correctly) to 6 (no test performed correctly) and these served as the outcome values for MCI. A detailed description of the MCI test battery and the definition of ratings can be found elsewhere (20).

Questionnaires

Basic demographic and clinical data were obtained from all participants. The Roland Morris Disability Questionnaire (RMDQ) (30) was used to screen for eligibility. Subsequently, participants answered the Fear Avoidance Belief Questionnaire (FABQ) (31), Fremantle Back Awareness Questionnaire (FreBaQ) (32) and Hospital Anxiety and Depression Scale (HADS) (33, 34). These questionnaires have been validated in the German language.

In addition, CLBP subjects were asked to report the locality of their pain (bilateral, left-sided or right-sided), its duration and mean intensity using a visual analogue scale (VAS). This scale ranges from 0 (no pain) to 100 (worst pain) (35).

Statistical analysis

All statistical analyses were performed using R (version 3.2.3) (36). Normality of data was determined by inspection of histograms. Demographics, questionnaire data, BPA, TPD and MCI were analyzed with descriptive statistics. Spearman correlations were used for all variables. We applied multiple logistic regressions with conditional likelihood to determine associations of the main outcomes (BPA, TPD and MCI) with the presence of CLBP. The log odds of the presence of CLBP were modelled with six covariates. These covariates were BPA, MCI and TPD (left and right horizontal TPD, left and right vertical TPD). The objective was to quantify the effect of each covariate on the outcome CLBP.

Results

Apart from Body Mass Index (BMI) which was higher in the CLBP group, the demographics of both groups were similar at baseline (Table 1). Table 2 illustrates the results of the assessments outcomes. BPA and TPD values were similar for both groups. Table 3 summarizes the results of the multiple logistic regression analysis. Significant between-group differences could be demonstrated for MCI only, with a statistically significant odds ratio of 0.65 for MCI (exp(coef) 1.92, 95%CI 1.00–3.68) for the presence of CLBP. This means that for each point greater on the MCI test battery the odds of being a patient with LBP increases 0.65 times. This result was not found for TPD or BPA. No statistically significant correlations between the independent variables were identified (Table 4). However, the results of the FABQ and FreBaQ demonstrated large differences between the groups (Table 2).

Discussion

The main objective of this study was to examine the ability of three commonly performed clinical tests to discriminate between CLBP patients and healthy controls. Our results revealed discriminative ability for the MCI test, but not for the BPA and TPD tests. Consequently, we can only recommend MCI as a test for this discrimination, due to its statistically significant odds ratio of .65 for the likelihood of having LBP.

This finding for MCI confirms previous results, in which discriminative ability was found between LBP patients and healthy controls (12, 18–21). Luomajoki et al. revealed a mean MCI score (out of 6) of 2.21 in patients with LBP and 0.75 in healthy controls (21). In contrast, both of our groups had higher MCI scores: 3.0 for CLBP patients and 2.0 for healthy controls. However, this current study only included patients with CLBP, whereas Luomajoki et al. also investigated patients with acute and subacute LBP (21).

Our results for the BPA test differ from previous research. Moseley et al (2005) used a similar approach with CRPS patients, demonstrating that patients selected photos with a 7% enlargement of the original size in the chronic pain group (22). In our study, both CLBP patients and healthy controls tended to choose enlarged photos of their backs and showed no meaningful between-group difference. Our BPA results indicate no significant association between an increased BPA score and a higher chance of having CLBP. However, different enlargement steps used in the Moseley et al. study could partly explain the different results. Our photos were modified in 3% steps, whereas Moseley et al. used 5% steps. In contrast to our study, the latter also demonstrated a correlation between the chosen picture and the duration of symptoms (22). BPA is a rather novel test for the detection of altered body perception, based on only preliminary data for CRPS patients, but it has not yet been validated for CLBP patients. Furthermore, our study investigated the trunk, whereas Moseley et al. focused on limbs, showing pictures of their both hands to participants. In the Moseley et al. study, the affected hand was modified, thereby allowing a comparison of both hands. In contrast, we only showed modified photos of one area at level, L4. Hence, the results of the two studies cannot be compared directly.

Our findings for the TPD test also diverge from previous studies that demonstrated a discriminative ability of TPD between CLBP patients and healthy controls (15, 17, 37). Luomajoki and Moseley also observed a correlation between the TPD and MCI tests (17). However, our study found no statistically significant correlation between TPD and MCI. Furthermore, no statistically significant correlations among the

independent variables were found. This accords with previous research. Ehrenbrusthoff et al. questioned the correlation between TPD and the FreBaQ questionnaire, by doubting the similarity of the underlying construct (38). However, recent studies have demonstrated correlations between TPD and body image drawings, which is another visual approach similar to BPA (23, 39).

This leads to the question of whether low baseline pain intensity of 33.4/100 VAS and disability of 8.2/24 in our patient cohort, which may cause less alteration at the cortical level could explain the inability of the included tests to demonstrate significant discriminative capability. Nevertheless, it remains unclear as to whether higher pain intensities and disability levels would result in greater discriminative ability between CLBP and healthy controls.

A methodological limitation of this study was that two different assessors performed the assessment of TPD to maintain blinding of all assessors. Catley et al. (2013) questioned the inter-rater reliability of TPD at the lower back (24). Therefore, this could have influenced our results.

Additional research is needed to improve BPA.. We suggest that enlargement steps should be increased from 3–5% and that the impact of smaller increments on significance be investigated. It is also unclear whether CLBP patients with higher activity levels would have different outcomes to CLBP patients with lower activity levels. Research has shown a change of proprioception and, therefore, movement control due to exercise (1, 40, 41). Moreover, a screening of the sample according to the criteria of the avoidance-endurance model of pain may result in more consistent findings.

Conclusion

We have investigated the ability of MCI, TPD and BPA tests to discriminate altered body perception in CLBP patients. Only MCI was shown to be valid in differentiating between CLBP patients with low to moderate pain and disability levels and healthy controls. However, further research is needed to elucidate the potential of all tests to detect CLBP patients.

Abbreviation List

Back-Photo Assessment	BPA
Body Mass Index	BMI
Chronic Low Back Pain	CLBP
Complex Regional Pain Syndrome	CRPS
Fear Avoidance Belief Questionnaire	FABQ
Fremantle Back Awareness Questionnaire	FrBaQ
Hospital Anxiety and Depression Scale	HADS
Low Back Pain	LBP
Movement Control Impairment test	MCI
Roland Morris Disability Questionnaire	RMDQ
Swiss Ethical Commission Northwest- and Central Switzerland	EKNZ
Two-Point Discrimination	TPD
Visual Analogue Scale	VAS

Declarations

Ethics approval and consent to participate

The Swiss Ethical Commission of Northwest and Central Switzerland (EKNZ) gave ethical approval (reference number 2015-243) to the study. All participants gave their informed consent prior to study start and all procedures conformed to the declaration of Helsinki

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

This article was developed equally be the first three authors. RM contributed to statistical data-analysis and writing. CE and CGW recruited and examined the participants and contributed to research plan, writing and statistical data-analysis. FP participated in statistical data-analysis and writing. AM calculated the statistics for the study and was involved in the research plan. HL and AS were involved in the design of the study. HL contributed to examination of participants and writing. All authors read and approved the final manuscript.

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Tables

Table 1

Demographic characteristics

	CLBP group (n = 30)		Healthy control group (n = 30)	
Variables	Mean	Range	Mean	Range
Gender female / male	15/15		15/15	
Age (years)	52.9 (SD 18.0)	25.0–83.0	51.8 (SD 16.5)	22.0–79.0
Weight (kg)	81.3 (SD 18.0)	50.0–122.0	72.0 (SD 11.9)	52.0–100.0
Body height (cm)	172.4 (SD 9.7)	157.0–194.0	173.1 (SD 8.7)	155.0–186.0
Body Mass Index	27.4 (SD 5.8)	16.9–44.6	24.0 (SD 3.0)	18.3–30.2
Affected side (bilateral / left / right)	17 / 3 / 10			
Pain duration (months)	131.8 (SD 160)	3.0–660.0		
Pain intensity (0–100)	33.4 (SD 20)	4.0–75.0		
RMDQ (0–24)	8.2 (SD 4.1)	4.0 - 21.0	0.07 (SD 0.3)	0.0–1.0
RMDQ: Roland Morris Disability Questionnaire				

Table 2

Outcomes

	CLBP group (n = 30)		Healthy control group (n = 30)	
Variables	Median	Range	Median	Range
BPA deviation steps (0–4)	2.0 (IQR 2.0)	0.0–4.0	2.0 (IQR 2.0)	0.0–4.0
BPA wider	18 (60%)		16 (53%)	
BPA slender	8 (26.5%)		10 (33.5%)	
BPA original	4 (13.5%)		4 (13.5%)	
TPD horizontal right (mm)	65.0 (IQR 33.8)	15.0–105.0	67.5 (IQR 23.8)	30.0–105.0
TPD horizontal left (mm)	67.5 (IQR 30.0)	30.0–120.0	57.5 (IQR 18.8)	25.0–140.0
TPD vertical right (mm)	45.0 (IQR 20.0)	20.0 – 110. .0	35.0 (IQR 33.8)	15.0–85.0
TPD vertical left (mm)	42.5 (IQR 20.0)	15.0–150.0	35.0 (IQR 28.8)	10.0–90.0
MCI positive tests (0–6)	3.0 (IQR 2.0)	1.0–5.0	2.0 (IQR 1.0)	0.0–5.0
FABQ (0–96)	33.0 (IQR 28.8)	0.0–96.0	1.0 (IQR 6.8)	0.0–37.0
HADS (0–42)	9.0 (IQR 5.5)	0.0–17.0	3.5 (IQR 5.8)	0.0–16.0
FreBaQ (0–36)	7.0 (IQR 6.8)	0.0–22.0	0.0 (IQR 2.0)	0.0–8.0
BPA: Back-Photo Assessment, TPD: Two-Point Discrimination, MCI: movement control impairment MCI: movement control impairment, FABQ: Fear Avoidance Belief Questionnaire HADS: Hospital Anxiety and Depression Scale, FreBaQ: Fremantle Back Awareness Questionnaire FreBaQ: Fremantle Back Awareness Questionnaire				

Table 3

Multiple logistic regression

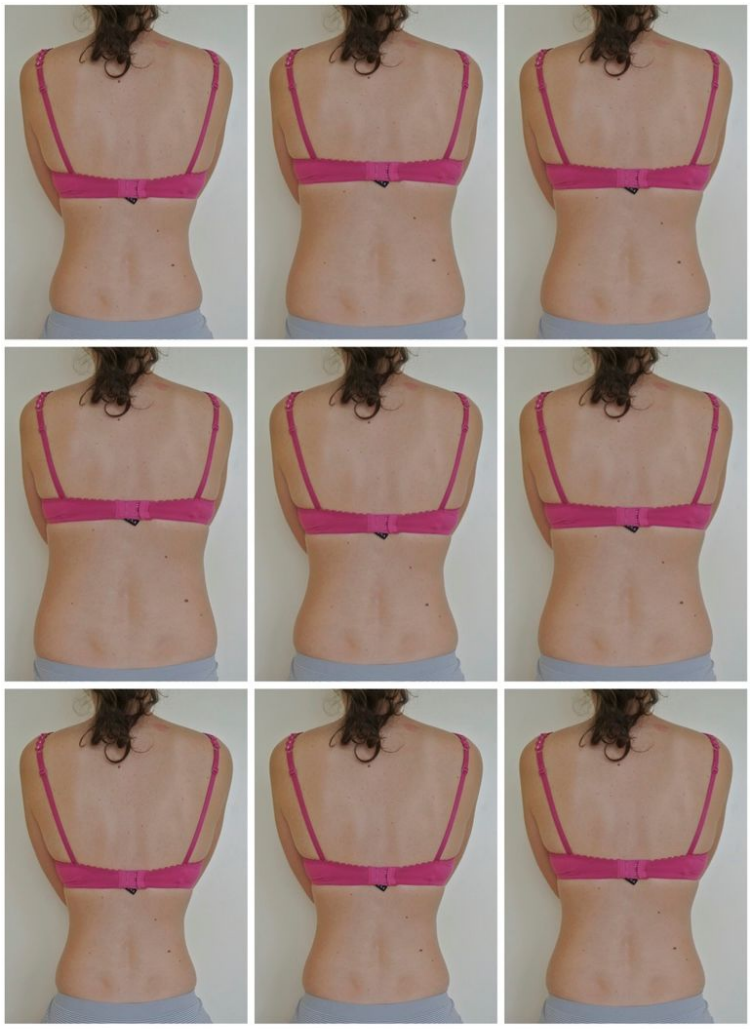
Variables	coef	exp(coef)	se(coef)	z	Pr(>|z|)	95% CI
BPA	-0.300512	0.7404	0.29043	-1.03473	0.30079	0.4191–1.308
TPD horizontal right	0.009997	1.0100	0.02481	0.40292	0.68701	0.9621–1.060
TPD horizontal left	-0.015363	0.9848	0.02734	-0.56185		0.9334–1.039
TPD vertical right	0.029290	1.0297	0.03171	0.92365	0.35567	0.9677–1.096
TPD vertical left	0.001855	1.0019	0.02318	0.08003	0.93621	0.9574–1.048
MCI	0.651199	1.9178	0.33215	1.96055	0.04993	1.0002–3.677
BPA: Back-Photo Assessment, TPD: Two-Point Discrimination, MCI: movement control impairment						

Table 4

Spearman correlations

Variables	TPD h right	TPD h left	TPD v right	TPD v left	MCI	FreBAQ	FABQ	HADS	Age	Body height	Body weight	BMI	BPA
TPD h right	1.000	0.790	0.408	0.318	-0.136	0.022	-0.026	0.077	0.296	0.049	0.458	0.454	0.232
TPD h left	0.790	1.000	0.591	0.580	-0.092	0.086	0.080	0.112	0.375	0.026	0.422	0.437	0.262
TPD v right	0.408	0.591	1.000	0.847	-0.086	0.225	0.165	0.197	0.207	0.036	0.123	0.178	0.170
TPD v left	0.318	0.580	0.847	1.000	0.009	0.172	0.166	0.021	0.047	0.051	0.106	0.149	0.248
MCI	-0.136	-0.092	-0.086	0.009	1.000	0.223	0.227	0.055	-0.206	0.222	0.247	0.140	0.086
FreBAQ	0.022	0.086	0.225	0.172	0.223	1.000	0.711	0.575	-0.162	-0.206	0.100	0.221	-0.093
FABQ	-0.026	0.080	0.165	0.166	0.227	0.711	1.000	0.592	-0.129	-0.123	0.042	0.116	-0.080
HADS	0.077	0.112	0.197	0.021	0.055	0.575	0.592	1.000	0.203	-0.077	0.199	0.271	0.070
Age	0.296	0.375	0.207	0.047	-0.206	-0.161	-0.129	0.203	1.000	-0.179	0.166	0.281	0.148
Body height	0.049	0.026	0.036	0.051	0.222	-0.206	-0.123	-0.077	-0.179	1.000	0.463	-0.026	0.001
Body weight	0.458	0.422	0.123	0.106	0.247	0.100	0.042	0.199	0.166	0.463	1.000	0.845	0.294
BMI	0.454	0.437	0.178	0.149	0.140	0.221	0.116	0.271	0.281	-0.026	0.845	1.000	0.350
BPA	0.232	0.262	0.170	0.248	0.086	-0.093	-0.080	0.070	0.148	0.001	0.294	0.350	1.000
BPA: Back-Photo Assessment, TPD: Two-Point Discrimination horizontal vertical, MCI: movement control impairment, FABQ: Fear Avoidance Belief Questionnaire, HADS: Hospital Anxiety and Depression Scale, FreBaQ: Fremantle Back Awareness Questionnaire, BMI: Body Mass Index, h: horizontal, v: vertical													

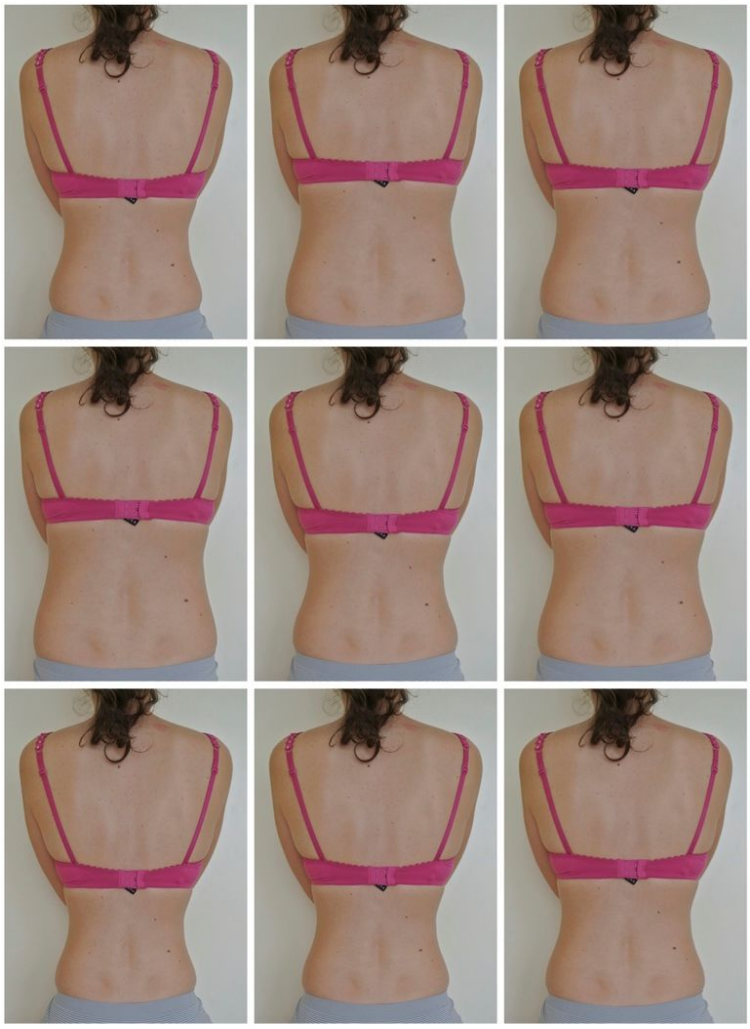
Figures



Back photo example
Order of the photos: 3 (-6%), 8 (+9%), 6 (+3%), 9 (+12%), 5 (original), 7 (+6%), 1 (-12%), 2 (-9%), 4 (-3%)

Figure 1

Back photo example BPA test.



Back photo example
Order of the photos: 3 (-6%), 8 (+9%), 6 (+3%), 9 (+12%), 5 (original), 7 (+6%), 1 (-12%), 2 (-9%), 4 (-3%)

Figure 1

Back photo example BPA test.

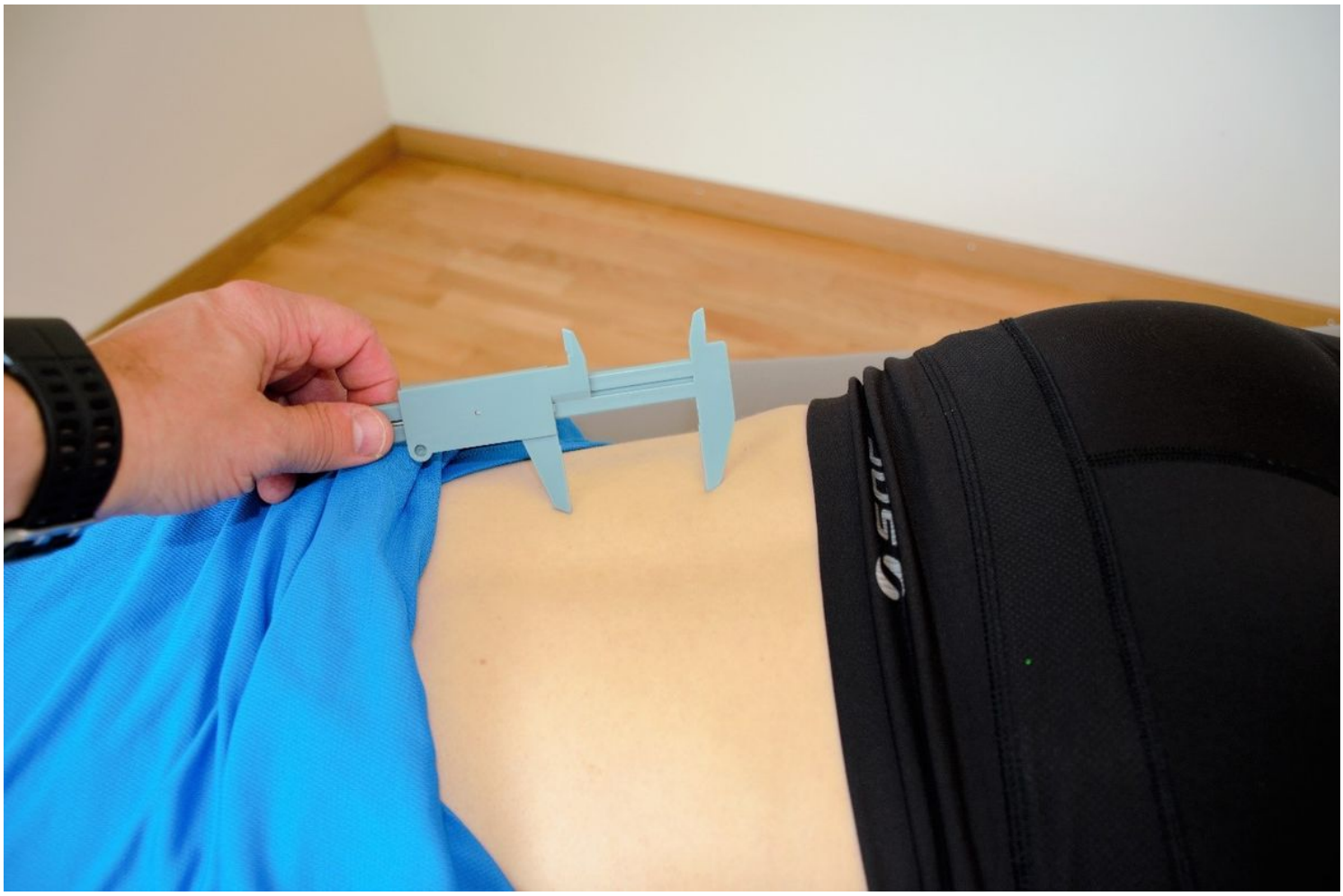


Figure 2

Two point discrimination (TPD) test.

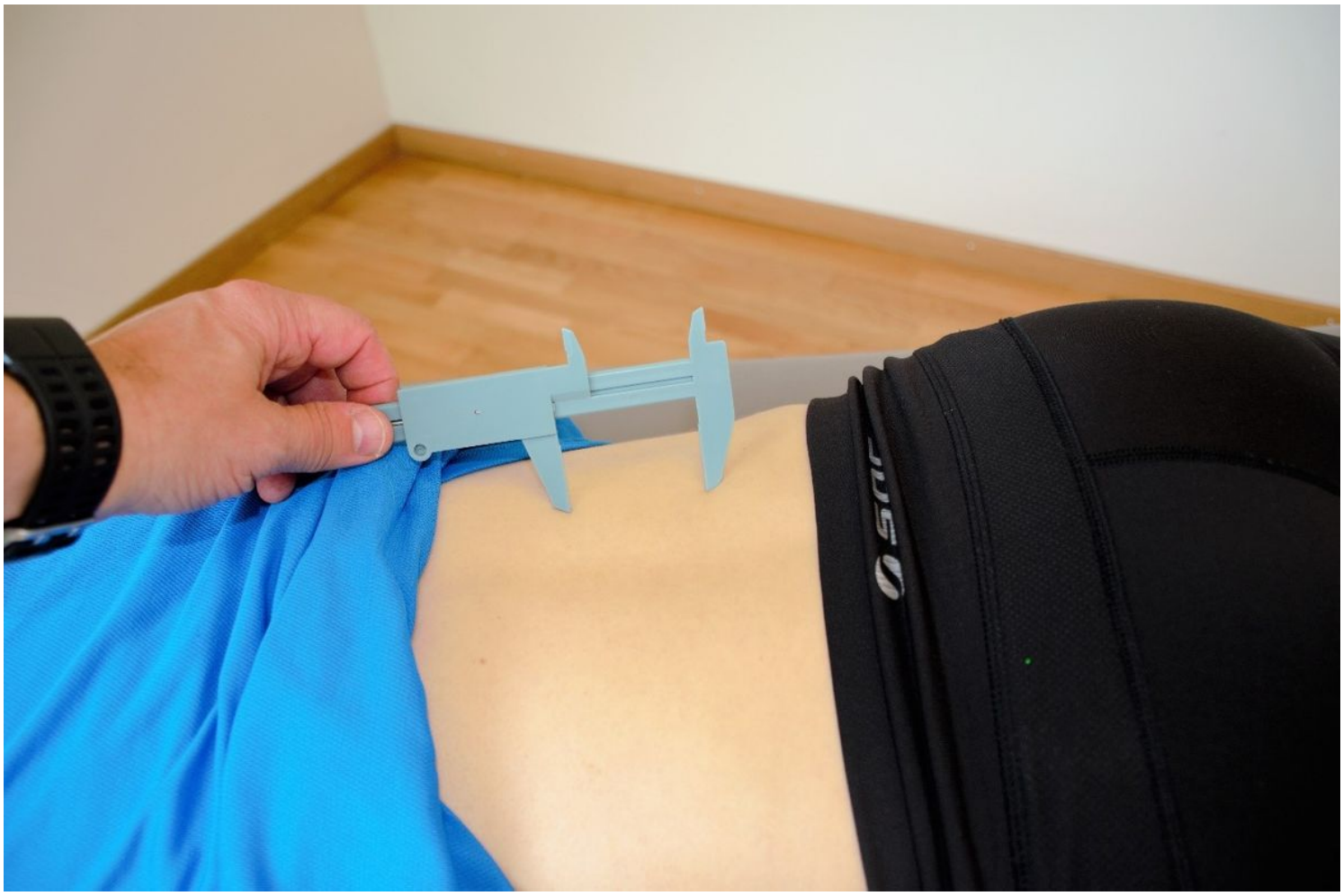


Figure 2

Two point discrimination (TPD) test.

Figure 3

Movement control tests (MCT)

Figure 3

Movement control tests (MCT)

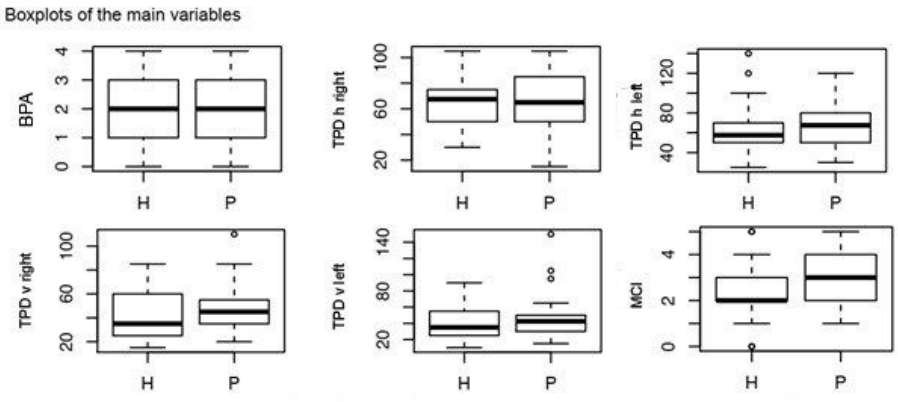


Figure 4

Group differences H: healthy controls, P: patients, BPA: Back-Photo Assessment, TPD v: Two-Point Discrimination vertical, TPD h: Two-Point Discrimination horizontal, MCI: movement control impairment

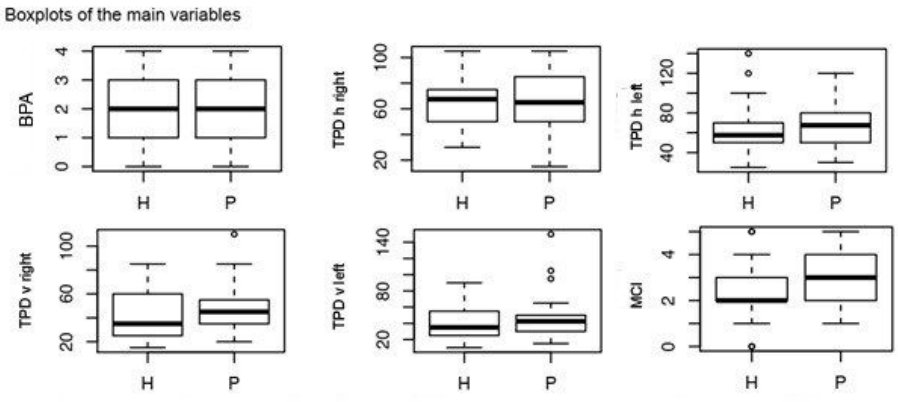


Figure 4

Group differences H: healthy controls, P: patients, BPA: Back-Photo Assessment, TPD v: Two-Point Discrimination vertical, TPD h: Two-Point Discrimination horizontal, MCI: movement control impairment

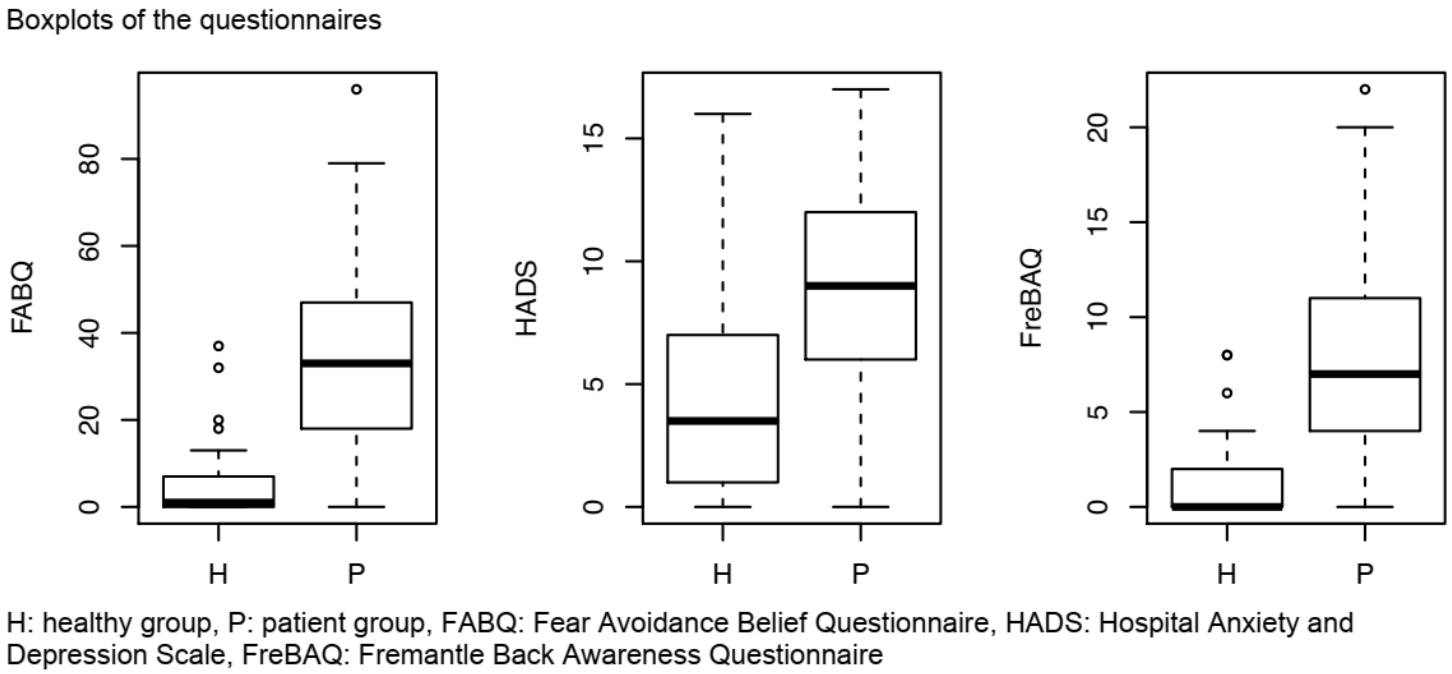


Figure 5

Group differences in questionnaires H: healthy controls, P: patients, FABQ: Fear Avoidance Belief Questionnaire, HADS: Hospital Anxiety and Depression Scale, FreBaQ: Fremantle Back Awareness Questionnaire

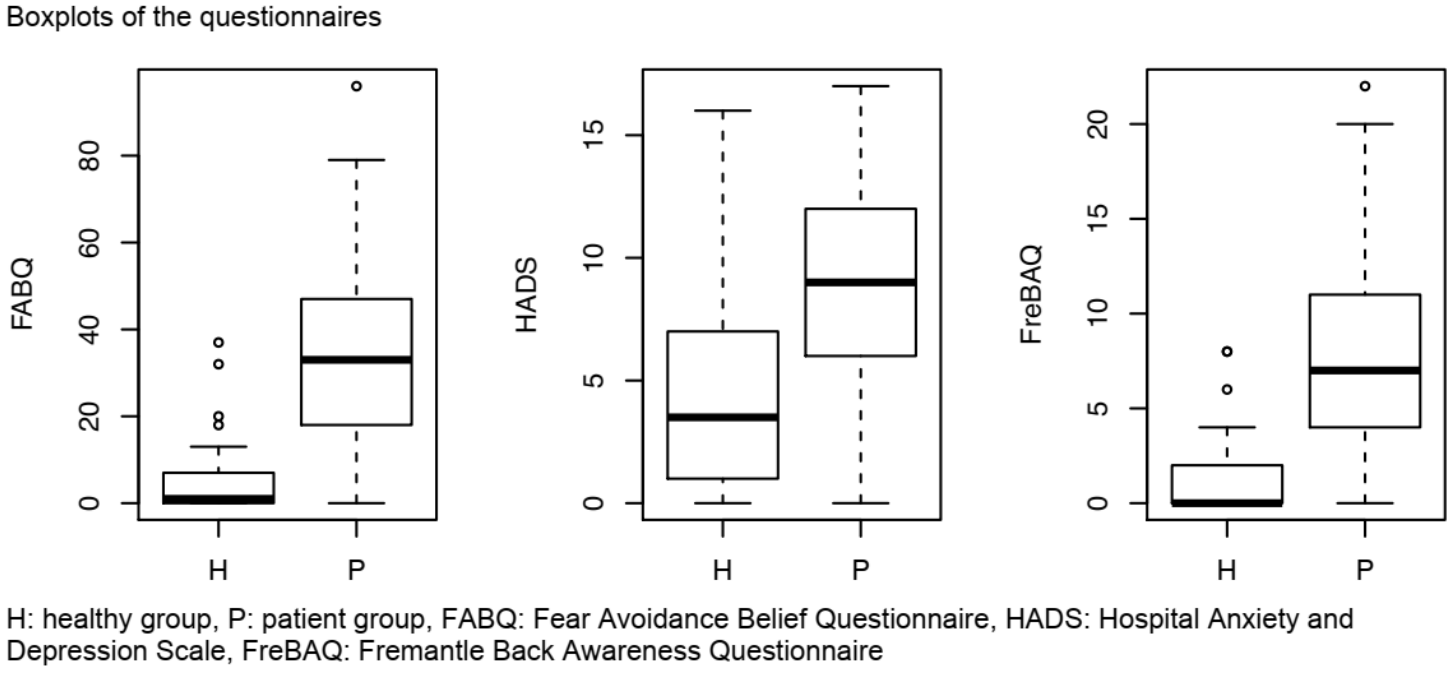


Figure 5

Group differences in questionnaires H: healthy controls, P: patients, FABQ: Fear Avoidance Belief Questionnaire, HADS: Hospital Anxiety and Depression Scale, FreBaQ: Fremantle Back Awareness Questionnaire