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Is physical functioning influenced by activity-related pain prediction and fear of movement in patients with subacute low back pain?

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ABSTRACT

In patients with low back pain (LBP), physical functioning may be negatively influenced by both expectations on pain and pain-related fear. It is unclear whether these factors influence both physical functioning in the laboratory as well as in daily life. The aim of this study was to test if a combination of persistent overprediction of pain and fear of movement predicts lab-based performance and whether these factors are relevant for predicting daily-life functioning.

One hundred and twenty four patients with subacute LBP performed a laboratory-based performance test twice. Maximum voluntary contraction, pre-test pain expectations, perceived pain during testing and fear of movement were measured. Patients were classified as correct or incorrect predictors, based on differences between expected and perceived pain on the second attempt. Next, physical activity in daily life was measured with an accelerometer.

In explaining physical functioning in the laboratory and in daily life an interaction effect between fear and pain prediction was observed. In overpredictors, fear was negatively associated with lab-based performance ($\beta = -0.48$, $p < 0.01$), and positively associated with daily-life functioning ($\beta = 0.50$, $p < 0.05$). No significant association between fear and performance or daily-life functioning were found in correct predictors.

In contrast to correct predictors, in overpredictors lab-based performance and daily-life functioning was additionally explained by fear of movement. Thus it appears that fear of movement is only predictive of performance in patients with LBP who simultaneously overpredict the consequences of movements in terms of painfulness.

1. Introduction

Patients with low back pain (LBP) and a high level of fear of movement often show poorer performance on laboratory-based physical tests and feel disabled in daily life (Vlaeyen and Linton, 2000; Leeuw et al., 2007). However, the association between fear of movement and objectively assessed performance has not consistently been found (Wittink et al., 2000; Verbunt et al., 2003). Another factor that may influence physical functioning is overprediction of pain (McCracken et al., 1993; Crombez et al., 1996). Patients with LBP that anticipate more pain than the actual activity may cause, might show avoidance (Philips, 1987). Only two studies directly examined the association between overprediction of pain and poor physical performance in the laboratory. One found that pain prediction was predictive of performance (McCracken et al., 1993). The other did not find an association (Goubert et al., 2005). One reason may be that both studies used the pain prediction score during the first confrontation with the physical performance test. Several studies demonstrated that most patients readily correct an initial overprediction after repeated exposure to the same test (McCracken et al., 1993; Crombez et al., 1996, 2002; Goubert et al., 2002). It may be speculated that patients that do not correct their expectations and persistently overpredict pain are prone to activity avoidance and performance decline.

It is, however, unclear whether fear of movement and overprediction of pain are independent or interdependent risk factors for performance decline. It may be assumed that especially patients with high fear of movement are prone to overestimate the activity-related pain, although previous studies found only weak or contradictory evidence for this (McCracken et al., 1993; Crombez et al., 2002; Goubert et al., 2002, 2005). An alternative interpretation could be that fear of movement and overprediction of pain interact

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in the explanation of physical performance, i.e., lower functioning levels may be especially prominent in patients who overpredict activity-related pain and have a higher level of fear of movement.

It can also be questioned whether the results from laboratory-based performance test generalize to daily-life functioning. In the laboratory, patients are confronted with unfamiliar tasks, whereas in daily life activities are usually recurrent, offering greater potential for adjustments of pain predictions. However, persistent overprediction in the laboratory may be indicative of patients' anticipation of activity-related pain more generally and thereby of activity avoidance in real life as well, thus limiting opportunities to correct an overprediction.

In sum, we tested whether laboratory-based performance is better predicted by the combination of (persistent) overprediction of pain and fear of movement and whether overprediction in the laboratory has relevance for daily-life functioning. Two hypotheses were specified.

(1) In patients with subacute LBP who do not correct their overprediction after one repetition of a novel movement, fear of movement has a greater negative impact on performance than in patients who correctly predict pain on the second occasion.
(2) Patients persistently overpredicting pain in the laboratory in combination with high pain-related fear also show declines in daily-life functioning.

2. Methods

2.1. Participants

In this study 124 patients with subacute low back pain (i.e., 4–7 weeks after pain onset) participated (Verbunt et al., 2005b). Inclusion criteria were: (a) low back pain: pain localized below the scapulae and above the gluteal folds (Merskey and Bogduk, 1994), (b) no significant activity limitations due to back pain in the last 3 months before the actual episode started, (c) age between 18 and 60, (d) no specific cause or strong suspicion of a specific cause, such as lumbar disc herniation with neurological complaints, major structural back abnormality, evidence of inflammatory, systemic or neoplastic disease. Exclusion criteria were (a) pregnancy; (b) muscle diseases; (c) serious psychiatric diseases; (d) cardiac pacemaker; and (e) non-fluency in Dutch. Patients were included in two different ways: they were referred by one of 29 general practitioners in South Limburg in the Netherlands or they responded to an advertisement in a local newspaper. To check the above mentioned selection criteria, a physician performed a medical screening according to the clinical guideline for low back pain of the Dutch College of General Practitioners (Faas et al., 1996). All patients gave their written informed consent prior to participation in the study. The Medical Ethics Committee of the Rehabilitation Foundation Limburg and the Institute for Rehabilitation Research, Hoensbroek, The Netherlands, approved the experimental protocol.

2.2. Physical measures

2.2.1. Physical functioning in a laboratory setting

Physical functioning in a laboratory setting was measured as the subject's maximum muscle strength, based on isometric muscle strength testing of the quadriceps muscle (Cybex II isokinetic dynamometer, Cybex, Ronkonkoma, NY). This task was chosen as representation for daily-life functioning because, in this test, patients need to anticipate on a new physical challenge. This situation resembles a daily life situation, in which patients have to deal with many unfamiliar activities. The reliability of isometric muscle strength testing of the quadriceps has been reported as moderate to high (Carpenter et al., 2006). Furthermore, the isometric quadriceps torque is related to self-reported physical functioning in patients with osteoarthritis (Pua et al., 2009). Subjects were asked to gradually build up force to a maximum level and then hold the muscle contraction for 5 seconds. Measurements were performed unilaterally on the preferred leg of the subject and expressed as maximum isometric peak torque. The maximum voluntary contraction (MVC) was standardized per kilogram lean body mass (MVC/LBM). Verbunt described the measurement protocol in detail (Verbunt et al., 2005a).

2.2.2. Physical functioning in daily life

Physical functioning in daily life was expressed as the subject's level of physical activity in daily life assessed by a tri-axial accelerometer (RT3; Stayhealthy Inc., Monrovia, USA). Acceleration signals from the three measurement directions (the sagittal, the mediolateral and the longitudinal axes of the trunk) were amplified and filtered. The resultant of the rectified acceleration from all three directions was calculated. The number of occasions per minute on which this signal exceeded a predefined threshold (counts) was counted. For every minute the number of counts was stored in a database within the accelerometer. Subjects were instructed to wear the RT3 during waking hours for 7 consecutive days. The final total activity score was expressed as the mean counts per day ($Activity_{mean}$). To be included as a valid physical functioning in daily life score, at least 5 measurement days, including 1 weekend day, had to be available (Gretebeck and Montoye, 1992). The tri-axial accelerometer is a valid instrument for the measurement of physical functioning in daily life in patients with LBP (Verbunt et al., 2001).

2.3. Self-report measures

2.3.1. Pain intensity

Immediately prior to the muscle strength effort, when the patient was already sitting on the Cybex chair, expected pain intensity during task performance was rated verbally on a numerical rating scale with extremes of 0 (no pain) and 100 (unbearable pain) (Bolton, 1999). In addition, after performing the task, patients were also asked to rate their perceived pain during task performance in an identical way.

2.3.2. Fear of movement/(re)injury

The Dutch version of the Tampa Scale for Kinesiophobia measures fear of movement. This questionnaire contains 17 items and is aimed at the assessment of fear of (re)injury due to movement. This version has a moderate internal consistency ($\alpha = 0.77$) and validity (Vlaeyen et al., 1995).

2.3.3. Disability

Low back disability was assessed using the Quebec Back Pain Disability Scale (QBPDS). This scale contains 20 items of which each item is rated from 0 (No difficulty performing this activity) to 5 (Impossible to perform this activity). The original as well as the Dutch version of the QBPDS are valid and reliable (Kopec et al., 1995; Schoppink et al., 1996).

2.4. Procedure

Questionnaires were filled out in the laboratory directly prior to the muscle strength assessment. Both the experimenter and patient were blinded for the exact strength assessment outcome. Data were stored on a computer. Patients were asked to predict pain intensity associated with the muscle strength task. Before the first attempt, each participant verbally rated the expected

intensity of pain during test performance. After actual test performance (s)he rated the pain intensity he/she actually perceived during testing. Subsequently, a second attempt based on an identical procedure was made. Before the second attempt patients were again asked to rate their expected pain. After the task perceived pain during the task was rated.

Since we were interested in persistent overprediction of pain, for further analyses the discrepancy in predicted and perceived pain scores during the second attempt were used. The first attempt was performed to become familiar with the task and to allow initial overprediction to be corrected. Differences (D) in pain prediction before and perceived pain during physical performance were then calculated by subtracting the level of perceived pain from the level of predicted pain. Based on this score for pain prediction accuracy, patients were classified in three pain prediction subgroups: patients who scored a D of -5 or below were classified as "underpredictor". Patients who scored in between -5 and 5 were labelled as "correct predictor". And finally, patients who scored a D of 5 or above were classified as "overpredictor".

2.5. Data analysis

In order to study the association between both fear of movement and pain prediction and physical functioning in the laboratory a hierarchical regression analysis was used. In the first step, MVC/LBM was the dependent variable in the model, and fear of movement (TSK), age, gender, and pain prediction group were introduced in the model as independent variables. In the second step the interaction term (fear × pain prediction group) was introduced. Furthermore, in case of a significant interaction, additional regression analyses were performed for both groups separately to identify influencing factors for physical functioning.

In order to study whether pain prediction in the laboratory is also associated with physical functioning in daily life, a hierarchical regression analysis was performed with $\text{Activity}_{\text{mean}}$ as the dependent variable and MVC/LBM, TSK, age, gender, and pain prediction group as the independent variables in the first step. We included MVC/LBP as an independent variable in the model to verify that the chosen performance test has indeed relevance for daily life performance. In the second step of the regression analyses the interaction between fear of movement and the pain prediction groups was added. If this interaction was significant, again additional regression analyses were performed for both pain prediction groups separately. In this, $\text{Activity}_{\text{mean}}$ was the dependent variable and MVC/LBM, TSK, age, and gender were the independent variables. For all regression analyses, a colinearity check was performed. Colinearity was considered a problem when the variance inflation factor (VIF) was above 3. Alpha was set at 0.05. All statistical analyses were performed using SPSS software (SPSS Inc., Chicago, Ill).

3. Results

3.1. Descriptive analyses

Mean age of the 124 patients (66 male and 58 female) was 44.1 years (SD = 10.3). Thirteen patients were excluded from the analyses. Reasons for exclusions were; no measurement of physical functioning in daily life (N = 9) or laboratory (N = 2), no registration of the pain prediction (N = 1) or non-completion of the questionnaire (N = 1). Reasons for the absence of data on physical functioning in daily life measurement were failure of the RT3 (N = 6) or an inadequate assessment period (less than 5 days) for the RT3 (N = 3). Patients included and excluded from further analysis were not significantly different as to age, gender or disability level. Frequencies per pain prediction group showed that for the first pain prediction, 62 patients overpredicted, 43 correctly predicted and five underpredicted their pain. As expected, overprediction of pain was readily corrected after the initial experience with the performance test in many patients. Prediction of pain for the second performance was accurate in 73 patients, 30 patients still overpredicted pain. Table 1 presents the patient characteristics per pain prediction group (based on the second performance test). The sample of the group "underpredictors" comprised only eight persons and was not included in any further analysis. There were no differences in age, gender, paid job, sick leave, or disability payment, between patients that overpredicted their pain (N = 30) and patients that predicted their level of activity-related pain correctly (N = 73). Furthermore, the level of fear of movement, and disability did not differ between the overprediction and correct prediction group.

3.2. The influence of pain prediction and fear of movement on physical functioning in the laboratory

In Table 2 the outcome of the regression analysis with physical functioning in the lab as dependent variable is presented. The inclusion of the variables in the first step did not yield a significant model. Thus, neither fear of movement nor overprediction of pain were associated with laboratory-based performance on their own. In the second step of this regression model the interaction term fear × pain prediction group was added which resulted in a significant model. The interaction contributed to the explanation of physical functioning in the lab. Fig. 1 presents the interaction between fear of movement and prediction subgroup for physical functioning in the laboratory. As can be seen from the figure, in correct predictors, fear of movement was not associated with physical functioning in the lab. However, for overpredictors an increase in the level of fear was associated with a decrease in laboratory-based physical functioning. To further explore the influencing fac-

Table 1
Characteristics of the study population.

	Underprediction group (N = 8)	Overprediction group (N = 30)	Correct prediction group (N = 73)
Male/female	5/3	18/12	36/37
Age	42.2 (13.6)	44.1 (11.0)	44.7 (9.9)
Work status (percentage)			
Paid job	6 (75%)	22 (73%)	50 (69%)
Sick leave	0	3 (10%)	12 (16%)
Disability payment	0	1 (3%)	7 (10%)
TSK[a]	38.8 (6.1)	35.1 (8.6)	36.1 (7.3)
QBPDS[b]	41.9 (16.4)	36.5 (18.0)	42.2 (17.7)

[a] TSK = Tampa Scale for Kinesiophobia.
[b] QBPDS = Quebec Back Pain Disability Scale.

Table 2
Regression analyses with physical functioning in the laboratory as dependent variable.

	Independent variables	R^2	Adjusted R^2	Standardized β
Step 1				
MVC/LBM	Age	0.08	0.04	−0.12
	Gender			0.18
	TSK			−0.16
	Pain prediction subgroups			−0.00
Step 2				
MVC/LBM	Pain prediction × TSK	0.16**	0.12**	0.49**

** $p < 0.01$.

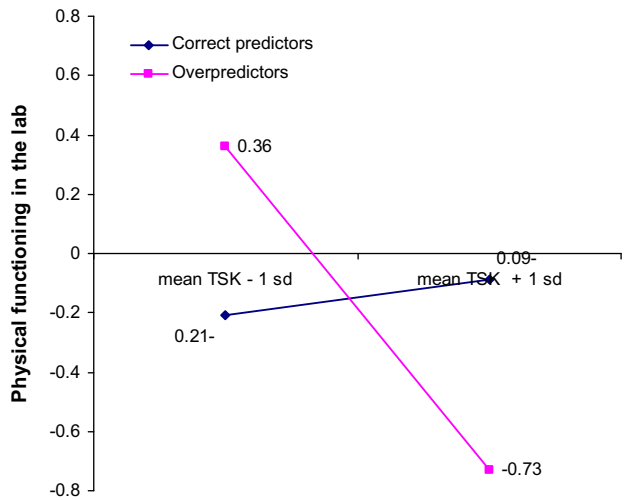

Fig. 1. The interaction between fear of movement and pain prediction subgroup for physical functioning in the lab.

Table 3
Regression analyses with physical functioning in the laboratory as dependent variable within the overprediction and correct prediction group.

	Independent variables	R^2	Adjusted R^2	Standardized β
Overpredictors				
MVC/LBM	Age	0.45**	0.39**	−0.35*
	Gender			0.05
	TSK			−0.48**
Correct predictors				
MVC/LBM	Age	0.04	0.00	0.01
	Gender			0.19
	TSK			0.06

* $p < 0.05$.
** $p < 0.01$.

tors for physical functioning within the overpredictor and correct predictor subgroup additional regression analyses per pain prediction group were performed (Table 3). In the overpredictor group a significant model was found. Age and fear of movement were significant predictors. In the correct predictor group no significant model was found.

3.3. The association between pain prediction in the lab and daily life physical functioning

Table 4 presents the regression model with physical functioning in daily life as dependent variable. As the first step in the analysis shows, physical functioning in daily life is related to physical functioning in the lab and age. There were no main effects of pain prediction group or fear of movement. However, in the second step of the analyses, a significant interaction was found between pain prediction group and fear of movement. Fig. 2 presents the interaction between fear of movement and pain prediction group for physical functioning in daily life. Whereas for the correct predictors fear of movement was not associated with daily-life functioning, for overpredictors, an increase in the level of fear of movement was associated with an increase in the level of physical functioning in daily life. Table 5 presents the regression models per pain prediction group with physical functioning in daily life as dependent variable. Only in the overpredictor group, fear of movement was significantly related to physical functioning in daily life. In all analyses, VIF factors were below 1.9 and no outliers appeared to be present.

Table 4
Regression analyses with physical functioning in daily life as dependent variable.

	Independent variables	R^2	Adjusted R^2	Standardized β
Step 1				
$Activity_{mean}$	MVC/LBM	0.17**	0.12**	0.20*
	Age			−0.23*
	Gender			0.15
	TSK			0.12
	Pain prediction subgroups			−0.07
Step 2				
$Activity_{mean}$	Pain prediction × TSK	0.20**	0.15**	−0.33*

* $p < 0.05$.
** $p < 0.01$.

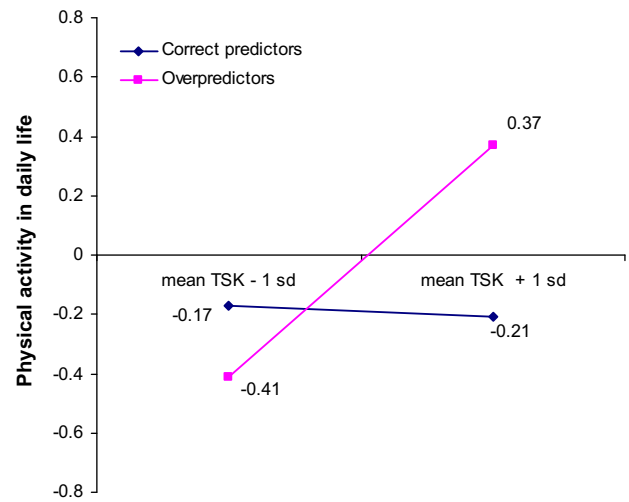

Fig. 2. The interaction between fear of movement and pain prediction subgroup for physical functioning in daily life.

Table 5
Regression analyses with physical functioning in daily life as dependent variable within the overprediction and correct prediction group.

	Independent variables	R^2	Adjusted R^2	Standardized β
Overpredictors				
$Activity_{mean}$	MVC/LBM	0.29	0.17	0.25
	Gender			−0.13
	Age			−0.41
	TSK			0.50*
Correct predictors				
$Activity_{mean}$	MVC/LBM	0.19**	0.15**	0.25*
	Gender			0.23*
	Age			−0.22*
	TSK			−0.03

* $p < 0.05$.
** $p < 0.01$.

4. Discussion

This study aimed to evaluate the influence of persistent overprediction of activity-related pain prediction and fear of movement on physical performance in the laboratory for patients with subacute low back pain. A second aim was to examine the influence of fear of movement and pain prediction on daily-life functioning.

The results indicated that in patients that correctly predict activity-related pain, fear of movement does not influence their lab-based performance, in contrast to persistent overpredictors in

whom a higher level of fear was associated with a lower performance level. This last finding supports the role of fear of movement in the overprediction group as described in the fear-avoidance model (Vlaeyen and Linton, 2000; Leeuw et al., 2007). This model describes how pain patients who are afraid of injury will have lower physical functioning levels compared to healthy individuals and who thus are prone to develop a deconditioning syndrome. In cases where persistent overprediction of activity-related pain is associated with higher levels of fear of movement, these patients may belong to a subgroup at risk for chronification of pain and development of this deconditioning syndrome. Deconditioning could not be confirmed in patients with chronic low back pain. However, pain-related fear and persistently overpredictions of activity-related pain were not taken into account (Wittink et al., 2000, 2002; Verbunt et al., 2003; Brox et al., 2005).

Furthermore, the influence of pain-related fear on physical capacity could not be unequivocally established. Whereas some studies indicate that, based on pain-related fear, patients who have lower levels of physical functioning can be distinguished from those who have levels comparable to healthy individuals (Al-Obaidi et al., 2000; Rudy et al., 2003; Goubert et al., 2005; Verbunt et al., 2005a), others found no influence of fear on functional capacity and maximum oxygen consumption (Smeets et al., 2006; Reneman et al., 2007). A possible reason for this could be that in the latter studies the patients with LBP were not divided into correct predictors and overpredictors of activity-related pain, and thus masking any influence of pain-related fear in the whole population of patients with LBP. Since lab performance testing is often used to simulate a patient's functioning in daily life, it is important to realise that for patients who overpredict activity-related pain a result from a performance test may be influenced by pain-related fear, which, in turn, may limit the generalizability to daily-life functioning.

In all patients, physical performance in the laboratory was marginally associated with their daily-life functioning, but in contrast to the laboratory findings, in daily life it appeared that patients who overpredicted their activity-related pain and experience more fear have a higher physical activity level in daily life. These contrasting findings on the effect of fear and the accuracy of activity-related pain prediction in either a lab-based or daily life situation are intriguing. It could be that patients who have high fear scores, will perform activities in daily life, but in a different manner (Thomas and France, 2007; Thomas et al., 2008). In the experiments by Thomas, patients with subacute low back pain had to reach three targets at a comfortable and a fast pace. Motion of the thoracic spine, lumbar spine, and hip were recorded. Patients with high pain-related fear indeed completed the movement but with a different strategy; they avoided motion of their lumbar spine (Thomas and France, 2007). Furthermore, they performed the fast pace reaching tasks with smaller peak velocities and smaller accelerations (Thomas et al., 2008). In a lab situation, patients are not able to choose their own performance strategy, since the activity often has to be performed according to a fixed protocol. The only possible way to cope with a feared activity is to submaximally perform during this activity. In our study, there was no alternative strategy possible to perform the quadriceps task, which could have resulted in submaximal performance for patients with high pain-related fear and overprediction. In contrast, in daily life, patients can use different performance strategies in order to reach the same goal. To avoid a feared activity (e.g., cycling) an alternative activity (e.g., walking) might be chosen to, eventually, reach the same goal (e.g., arriving at the shop). In this example the alternative strategy (walking) necessitates even more energy expenditure as compared to the avoided activity (cycling), eventually resulting in a higher level of physical activity in daily life as a result of fear.

One limitation of the current study is the low number of patients that underpredicted their pain, which hampered processing the data of this group in the statistical analyses. The question thus remains, whether underpredictors, who do not seem to anticipate on an activity-related pain increase, indeed experience a pain increase after strenuous activities in their daily-life functioning. It is hypothesized that this could be the group of patients with chronic pain with the highly fluctuating activity pattern as described in the avoidance endurance model (Hasenbring et al., 2001, 2006). In addition, in the current study, information on expected pain and perceived pain out of the lab situation was used as an indicator for activity-related pain prediction during physical performance in daily life. This raises the question whether patients that overpredict pain in the laboratory also overestimate a pain increase as a result of a strenuous activity resulting in avoidance of these activities during the day. It was hypothesized that this group of patients do not participate in many strenuous activities that lead to an increase of pain. To further unravel the interaction between activity, fear and pain in daily life, additional information could be gathered by combining daily activity assessment using an accelerometer, in combination with a diary in which pain, fear and even expectations will be registered.

An other limitation of this study is the use of a verbal numerical rating scale for expected and perceived pain that is a 101 point scale. However, patients tend to use 5 or 10 point steps reducing it to a 21 points scale. Furthermore, patients remember their expected pain score and this may influence their perceived pain. In this study we chose to interpret a score between −5 and 5 as a correct prediction in contrast to research on the match–mismatch model. In the latter studies pain was rated on a 10 cm visual analogue scale and a score between −2 and 2 was interpreted as a correct prediction (Rachman and Lopatka, 1988; Murphy et al., 1997).

This study has several clinical implications. In evaluating the functioning of the patient with subacute LBP with a physical task, in patients that persistently overpredict their activity-related pain, higher levels of fear of movement are associated with a lower performance. This group of patients could be prone to develop a deconditioning syndrome with a higher disability level as described in the fear-avoidance model. Furthermore, in evaluating functioning with a performance task in which non-physiological factors can influence performance, it is important to realise that overpredictions of pain and pain-related fear can influence with the test outcome.

In summary, in the current study in patients who do not correct their overprediction of pain after a physical performance in the laboratory, higher levels of pain-related fear were associated with a lower performance level in a laboratory setting, whereas in daily-life functioning this was associated with a higher functioning level. For patients that predicted their pain correctly, pain-related fear had no influence on lab-based performance or daily-life functioning.

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