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A Study of the Clinical Utility of the BPI-12 and 23 in Predicting Shoulder Pain in Stroke Patients

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Abstract. [Purpose] This study was designed to evaluate the clinical utility of the Brief Pain Inventory-12, 23 (BPI-12, 23) for predicting shoulder pain in stroke patients and to compare the functional ability of the BPI-12, 23 test to discriminate between subgroups with and without shoulder pain. [Subjects] The subjects were 62 persons who were chronic stroke survivors with shoulder pain. [Methods] The patients answered questions on shoulder pain using the BPI question 12 (BP1-12) and Pain-related Quality of life (BPI-23). Therapists measured the performance of combined upper-limb movements including the hand behind the neck (HBN) maneuver, and added passive pain-free shoulder external rotation range of motion, and the Modified Ashworth Scale (MAS) score of the elbow flexors. Physical performance assessments were used to measure basic activities of daily living (Modified Barthel Index, MBI), the motor function of the upper limb (Fugl-Meyer Upper/Lower Extremity, FM-U/E). [Results] A BPI-12 score of > 4.25 and a BP1-23 score of > 5.5 showed high probability of the presence of hemipelgic shoulder pain (respectively, Sensitivity = 77%, 77%; Specificity = 77%, 69%; Receiver Operating Characteristic [ROC] =0.81, 0.76; 95% Confidence Interval [CI] = 0.70–0.92, 0.64–0.88). [Conclusion] The BPI-12 and 23 both have potential as screening tools for risk factors of shoulder pain. They can be performed during evaluation to increase the likelihood of determining those who complain of hemiplegic shoulder pain after stroke. However they first require confirmation in a prospective study.
Key words: Shoulder pain, Stroke, Brief Pain Inventory

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INTRODUCTION

Shoulder pain after stroke is one of the four most common complications. The pain severity is different depending on the causes of the pain, and patients suffer various senses of pain[1, 2)]. About 17% of stroke patients suffer shoulder pain within one week after stroke[2)]; 55% of them suffer it within two weeks[3)]; 87% of them suffer it within two months[3)]; and 75% of them suffer it within one year[4)]. The initial attack of shoulder pain in stroke patents prevents is patients from recovering their upper extremity function because the non-paralyzed upper extremity is overused in performing functional exercises; therefore, the patients' upper extremity function is reported to improve within five weeks after the attack[5)]. Stroke patients have many different musculoskeletal shoulder disorders, such as shoulder muscle atrophy, shoulder and humeral joint instability, rotator cuff tear, frozen shoulder, tendinitis of the suprasupinatus, shoulder hand syndrome, and biceps tendon rupture[6, 7)]. Lo et al.[8)] revealed eleven causes of shoulder pain when they examined patients within two months after stroke using arthroscopy. According to their study, 50% of the patients suffered adhesive capsulitis, and the incidence rate within one year reached 74%[9)]. In a stable condition, shoulder pain showed a significant correlation with the joint range of motion of the affected shoulder external rotation[3)], and the affected shoulder external rotation is related to the time (r=–0.538) since stroke attack[8)]. Also if patients suffer severe shoulder pain after stroke, shoulder external rotation becomes limited within three months[10, 11)]. In particular, the restriction of shoulder range of motion causes contracture of soft tissue[8)], and stroke patients with hemiplegic shoulder pain show histologic changes such as synovial hyper-vascularity[12)], cell growth, and leukocyte count increase around growth β factor, fibroblasts, and intracapsular blood vessels[13, 14)]. Intracapsular adhesion, especially restricts passive shoulder external rotation[15)], and causes 65% of stroke patients to suffer muscle weakening regardless of humeral degenerative changes in the recovery period after stroke[3)]. Patients who have low muscle tone around the unaffected shoulder and hemiplegic shoulder are highly likely to be exposed to humeral joint instability and impingement syndrome[13, 16–18)]. Accordingly, structural and histologic changes in the shoulders create a vicious cycle of shoulder pain, and since patients are afraid of the damage, their social activities can be restricted and the movement of their upper extremities is limited. For these reasons, it is important to recognize the preliminary factors of the pain,

Table 1. Subject characteristics

	Characteristics	n(%)	Variables	mean ± SD
Gender	Male	35(56.5)	[a]HBN(score)	4.35 ± 2.11
	Female	27(43.5)		
Age(years)	40–49	10(16.1)	Elbow flexor tone(score)	1.02 ± 0.50
	50–59	22(35.5)		
	60–69	21(33.9)	[b]BPI-12(score)	4.53 ± 2.57
	70 over	9(14.5)		
Etiology	Cerebral infarction	36(58.1)	[c]BPI-23(score)	5.48 ± 2.61
	Cerebral hemorrhage	26(41.9)		
Type	Left hemiplegia	35(56.5)	Pain-free shoulder external rotation ROM(°)	40.15 ± 23.47
	Right hemiplegia	27(43.5)		
Duration	6 month over ~ 1 years below	45(72.6)	[d]MBI(score)	82.77 ± 13.47
	1 years over	17(27.4)		
			[e]FM-U/E(score)	38.52 ± 21.80

Abbreviation: [a]HBN: Hand Behind Neck, [b]BPI-12: Brief Pain Inventory-12, [c]BPI-23: Brief Pain Inventory-23, [d]MBI: Modified Barthel Index, [e]FM-U/E: Fugl-Meyer Upper Extremity

and the most effective way to reduce the pain is to prevent the occurrence of those factors. The apprehension, Neer and sulcus tests are ways of examining humeral joint instability and impingement syndrome of the subacromial space[19], but their reliabilities are known to be very low as a clinical test for stroke patients for precisely diagnosing musculoskeletal problems related to shoulder pain in a pathophysiological way[12]. According to a study of thirty elderly patients by Von Korff et al.[20], if shoulder pain has a Numeric Rating Scale (NRS)≥5 in a stable condition, it is severe. A study of stroke patients by Rajaratnam et al.[12] also reported the same result, and they further revealed that if NRS is less than 5, it means that there is no pain or light pain. Hand behind neck (HBN) is another way of examining postures (shoulder external rotation and abduction) causing shoulder pain after stroke. In the test the palms are put on the back of the neck in order to examine shoulder pain. If NRS is 5 or over, it means that there is shoulder pain[21]. This test records the severity of pain which patients feel as they functionally move their upper extremities through postures causing shoulder pain. Since variables like pain may not inhibit patients from adopting some postures, and since patients are positively encouraged to adopt the basic postures necessary in everyday life, pain may influence their satisfaction with life[6].

The Brief Pain Inventory question (BPI question-12, BPI-12; BPI question-23, BPI-23) is a clinical test used to investigate stroke patients' satisfaction with their life related to the severity of shoulder pain[22]. BPI-12 and BPI-23 are self-administered surveys, and are helpful for investigating the influence of the shoulder pain and its severity on patients' everyday lives. Accordingly, the purpose of this study was to investigate the predictive value of the BPI-12 and BPI-23 for shoulder pain in stroke patients, and to determine the cutoff point for shoulder pain. In addition, we also investigated the differences in the functional performance abilities of patients.

SUBJECTS AND METHODS

This study was conducted from May 2010 to March 2011. The subjects were 62 stroke patients with hemiplegia who were hospitalized in N medical center and agreed to participate in this research. The patients engaged in this research understood the research and were able to communicate (MMSE >23 points). In the sitting position subjects received an examination in which one of the researchers used an index finger to palpate the part between the humeral head and subacromial space of the paralyzed upper extremity without manual traction. Subjects who, according to the palpation, had no shoulder subluxation in which the gap between the spaces was greater than one half a finger width were included in the study[6, 23]. Those who had no lower motor neuron disease, and who suffered orthopedic disorders of the shoulders or shoulder pain before stroke were excluded (Table 1).

The HBN is a test which determines the severity of pain in shoulder external rotation and abduction when putting the palms on the back of the neck, and its inter-rater reliability (ICC=0.98) is reported to be high[12]. Therapists instruct patients to verbally express the severity of shoulder pain, which they subjectively feel as a numeric rating when they manually operate patients' paralyzed upper extremities[21]. NRS ranges from 0 to 10 points: 0, no pain; 10, excruciating pain. It is reported to have high validity and sensitivity in the evaluation of the severity of pain of the elderly and stroke patients[20]. When functional movement of the upper extremities is performed in the HBN test, if shoulder pain is assessed as NRS≥5 points, it means that patients feel the pain with the inverse value of the probability of which the pain appears[12, 15]. In the HBN test, it was reported that for a NRS≥5 in the determination of pain in a stable condition, the ROC curve is 0.845, Sensitivity is 96.7 and Specificity is 72.4[12]. We used these figures to determine shoulder pain NRS≥5 points (pain) and NRS<5 points (no pain) in the HBN test.

Table 2. ROC curves for the values of BPI-12 and 23 discriminating between with and without shoulder pain

Variable	Cutoff point(score)	Sensitivity (%)	Specificity (%)	AUC (95% CI)
[a]BPI-12	4.25	77	81	0.81 (0.70~0.92)
[b]BPI-23	5.5	77	69	0.76 (0.64~0.88)

Abbreviation: [a]BPI-12: Brief Pain Inventory-12, [b]BPI-23: Brief Pain Inventory-23

In this study, BPI questions were used to evaluate satisfaction with life related to shoulder pain and its severity, and to investigate information on the pain[22]. BPI-12 was used to evaluate the severity of pain over the last 24 hours. The level of the severest pain, the level of the weakest pain, the level of average pain, and the level of the current pain was assessed, and the arithmetic mean of the four question's response scores was calculated. In the survey, the higher the total score of the four questions is, the more severe the pain is. The survey's rating is the same as NRS. Regarding satisfaction with life related to pain, BPI-23 was used to evaluate the influence of the 24 hour pain on patients' daily lives, such as overall activities (eating, bathing, evacuating, and dressing), feeling, walking ability, ordinary work, personal relationship, sleeping, and enjoyment of life through seven questions, and the arithmetic mean of the response scores ware calculated. In the survey, the higher the total score is the more influential the pain is on everyday life. In other words, 0 means the pain is not influential on everyday life, and 10 means it is considerably influential. The survey is self-administered, and its internal reliability or Cronbach's alpha is 0.92, which demonstrates high reliability[22].

To minimize the confusion effect of pain caused by shoulder manual contact, the Modified Ashworth Scale (MAS) was used to evaluate paralyzed elbow flexor tone. For most stroke patients, shoulder external rotation and abduction is reduced regardless of their upper extremities' muscle tone, so it is difficult to precisely evaluate muscle tone. Accordingly, this study chose elbow flexor tone on the assumption that elbow muscle tone is usually present[6]. MAS has high inter-rater reliability (weight κ=0.77–0.96) and intra-rater reliability (weight κ=0.77–0.83)[24]. Its score ranges from 0 to 4, and high points mean hypertone, and low tone means flaccidity of the upper extremities.

Testers made use of a goniometer to manually evaluate the range of motion of shoulder external rotation with no pain of patients' paralyzed upper extremities, and recorded the angles[10, 25].

Fugl-Meyer Upper/Extremity-function is designed to evaluate the functional recovery of stroke patients. We used it to evaluate upper extremity function of the subjects[26]. The upper extremity was divided into shoulders/elbows/forearms, wrists, hands (fingers), and coordination. The maximum score of the test is 66. It is reported to have high inter-rater (r=0.94), and intra-rater reliabilities (r-=0.99)[27].

The Barthel Index was developed by Mahoney and Barthel[28] and assesses self-reliance in everyday living activities to evaluate patients' functional improvement. It consists of ten everyday life activities, seven questions about self-care and three questions about mobility. Each item is scored from 0–5: 0–24 points mean full reliance; 25–49 points great reliance; 50–74 partial reliance; 75–90 slight reliance; 91–99 the least reliance; and 100 full self-reliance. The test is known to have test-retest reliability of r=0.89 and inter-tester reliability of r=0.95[29].

SPSS ver. 16.0 was used to analyze the subjects' general characteristics, and the Shapiro-Wilk test was used to test the normality of variables. BPI-12 and 23 along with receiver operation characteristic curve (ROC curve), which was used to determine the standard value of the testing method, were used to determine the optimal cutoff value of shoulder pain prediction. In addition, in the event that the cut off value was significant, the χ^2 test was performed to investigate the relationship between subjects' cutoff values and NRS pain; the independent *t*-test was conducted to evaluate functional performance ability. Statistical significance was accepted for values of α<0.05.

RESULTS

The results of ROC curve analysis for BPI-12 and 23 revealed that the cutoff values for predicting shoulder pain with BPI-12 and BPI-23 were respectively 4.25 (sensitivity: 77% and specificity: 81%) and 5.5 (sensitivity: 77% and specificity: 69%). Also, the AUC (area under the ROC curve) for BPI-12 and BPI-23 were respectively 0.81 (95% CI:0.70–0.92) and 0.76 (95% CI:0.64–0.88) (Table 2).

When two groups were created according to the cutoff value of BPI-12 (NRS≤4.25, >4.25 points), the group with no shoulder pain showed statistical differences from the shoulder pain group in terms of HBN, BPI-23, pain free range of motion of shoulder external rotation, and FM-U/E, but there were no significant differences in terms of elbow flexor tone and MBI. When two groups were created according to the cut off value of BPI-23 (NRS≤5.55, >5.5 points), the group with no shoulder pain showed statistical significant differences from the group with shoulder pain in terms of HBN, BPI-12, pain free range of motion of shoulder external rotation, MBI, and FM-U/E, but there was no significant difference in elbow flexor tone (Table 3).

DISCUSSION

Shoulder pain after stroke is significantly related to reduction in satisfaction with life[6, 30, 31], and range of motion of shoulder external rotation is related to upper extremity function[3, 8]. Regardless of the direction of the upper extremity, the humeral head needs minimal subacromial space lest it should impinge against the glenoid fossa. The humeral head has stability and mobility due to shoulder

Table 3. Comparison of functional ability between with and without shoulder pain of BPI-12 and BPI-23

Variables	BPI-12(n=33) (≤4.25score)	BPI-12(n=29) (>4.25score)	Variables	BPI-23(n=29) (≤5.5score)	BPI-12(n=33) (>5.5score)
[a]HBN(score)	3.15 ± 1.81	5.72 ± 1.51**	HBN(score)	3.38 ± 1.90	5.21 ± 1.92**
Elbow flexor tone	0.54 ± 0.56	1.10 ± 0.41	Elbow flexor tone	0.93 ± 0.53	1.09 ± 0.46
[b]BPI-23(score)	4.58 ± 2.61	6.52 ± 2.23*	BPI-12(score)	3.39 ± 2.33	5.53 ± 2.38**
Pain-free shoulder external rotation(°)	50.06 ± 24.18	28.86 ± 15.46**	Pain-free shoulder external rotation(°)	48.24 ± 24.19	33.03 ± 20.64*
[c]MBI(score)	85.36 ± 13.67	79.83 ± 12.83	MBI(score)	87.86 ± 12.10	78.30 ± 13.18*
[d]FM-U/E(score)	45.79 ± 20.08	30.24 ± 21.00*	FM-U/E(score)	48.52 ± 17.82	29.73 ± 21.39**

NOTE. Values are mean ± SD. Abbreviation: [a]HBN: Hand Behind Neck, [b]BPI-23: Brief Pain Inventory-23,[c]MBI: Modified Barthel Index, [d]FM-U/E: Fugl-Meyer Upper Extremity. *p<0.01, **p<0.001 by independent *t*-test.

external rotation (infraspinatus and teres minor)[32]. Shoulder external rotation is certainly needed for the supraspinatus and tendon to freely be moved as patients raise or stretch out their arms. In particular, since shoulder external rotation supports vertical displacement in the subacromial space, if the movement didn't happen, the humeral head experiences lack of vertical displacement and the subacromial bursitis impinges against the supraspinatus in the subacromial space causing chronic pain which leads to functional limitations[7]. Biomechanical movement is associated with pure upper limb movement such as stretching out the hands, raising the hands, eating, dressing, operating a wheelchair, turning the arms, and bathing, all of which are everyday living activities[12]. Shoulder pain of stroke patients restricts their upper limb movement and causes passivity in everyday living activities. As patients with an unstable shoulder elevate their upper limbs, shoulder impingement occurs[32]. Regarding this issue, Rajaratnam et al.[12] argued the necessity of a dynamic test for the shoulder joint to test stroke patients as they elevate their upper limbs. A few researchers have demanded precise information on shoulder pain, since there are diverse pathological opinions on the pain of stroke patients[33]. According to Price et al.[33], the severity of shoulder pain varies depending on the type of stroke, and Bohannon and Andrews[16] argued that the method for evaluating shoulder pain is the most important factor. Constant and Murley[21] used the HBN test for orthopedic patients to evaluate their shoulder pain in terms of functional performance. Shoulder external rotation and abduction are performed together in the HBN test. If the cutoff value of shoulder pain is NRS≥5 points, it means that the pain is severe, and 20% of stroke patients suffer severe pain (NRS≥5 points) in the early stage of stroke[12]. In addition, a study of 54 stroke patients showed the same result[15]. Accordingly, the upper extremity function of the combination of shoulder external rotation and abduction can be utilized as an index of pain caused by everyday living activities and satisfaction with life. According to an early 1980 report by the World Health Organization, satisfaction with health and life is not only restricted to diseases, but physical, psychological and social health[34]. Recently, satisfaction with life includes physical, emotional, functional, and social areas, and focus on individual pain, diseases and functional disorders[35]. Based on such concepts, this study used BPI-23 to evaluate the satisfaction with life related to pain arising in overall activities, feeling, walking ability, ordinary works, personal relationship, enjoyment of life, and sleeping. The severity of pain restricts social activities and encourages passive attitudes to everyday life activities making patients reluctant to engage in activities. In addition, it undermines self-activities and causes psychological barriers so that patients are faced with difficulties in performing specific movements through their voluntary efforts[6].

This study used BPI-12 and 23 to investigate the cutoff value for predicting shoulder pain in stroke patients, and examined the clinical values evaluating patients' functional performance ability. This study was based on previous studies of severity of pain which attempted to predict a cutoff value. NRS>4.25 points and NRS>5.5 points for BPI-12 and -23, respectively, distinguish groups with high probability of the experiencing of shoulder pain. In other words, patients who have more than 4.25 points or 5.5 points have higher probabilities of experiencing pain than those who do not. Both BPI-12 and 23 had sensitivities of 77%, and for the true negative, BPI-12 and BPI-23 showed sensitivities of 81% and 69%, respectively. The BPI-12 test has a higher true negative sensitivity than BPI-23 indicating that BPI-12 is a more precise test for identifying patients with no shoulder pain. BPI-12 is needed to evaluate the severity of pain, and BPI-23 is needed to evaluate satisfaction with life related to pain negatively influencing everyday life. BPI-12 records the severity of pain which patients suffer during 24 hours, and BPI-23 records the restriction of activities caused by passive attitudes and avoidance of seven movements in everyday life, and some movements can be over-and under-evaluated. Patients' BPI-23 average score was higher than that of BPI-12, but the results of cross analysis showed that in terms of the cutoff value, 30 out of 62 patients (48.4%) had >4.25 points in BPI-12, and among them, 24 patients (80%) had NRS≥5 points. Also, 33 out of 62 patients (53.2%) had >5.5 points in BPI-23, and among them, 23 (69.7%) patients had NRS≥5 points. Therefore, there was statistically significant difference in shoulder pain according to the cutoff value.

Since we did not perform quantitative analysis of shoulder subluxation of the stroke patients participating in the study, selection bias influencing the severity of pain,

upper extremity function disorder and range of motion of shoulder external rotation may have arisen in the HBN test[36]. However, subjects' mean FM-U/E score was 38.52, out of 66 points, their MBI was 82.77, out of 100 points, and their pain free range of motion of shoulder external rotation was 40.15°. These are relatively high values, so we consider that shoulder subluxation scarcely affected functional performance ability. FM-U/E and MBI, in effect, may negatively influence upper extremity function due to reciprocal action of the level of shoulder subluxation and pain severity. Nevertheless, subjects had no difficulties in performing their assigned movements.

In the comparison between the two groups of BPI-12 (≤4.25, >4.25 points) and BPI-23 (≤5.5, >5.5 points), the group without shoulder joint pain showed statistically significant differences in HBN, BPI-23, painless shoulder joint external rotation motion range, FM-U/E compared to the group with pain, but not in elbow joint flexion stiffness. However, in BPI-23, there was a significant difference in MBI, because unlike BPI-12, BPI-23 contains performances tasks related to daily life (eating, bathing, excretion, dressing, walking) similar to MBI in its contents. The study of Rajaratnam et al. (2007) showed that NRS≥5 points have high accuracy in measuring whether there is pain when patient's joint is moved passively. But it is obvious that there is difference in cutvalue when patient perform a movement actively. BPI-12 evaluates the degree of pain experienced in the last 24 hours and BPI-23 evaluates the degree of pain interfering with daily life.

This study showed that if scores are more than >4.25 in BPI-12, or >5.5 in BPI-23, HBN (shoulder external rotation, supination motion) posture causing shoulder joint pain is 5.72 points, or 5.21 points; therefore, it could be confirmed that there was pain and that is can act as a negative element in performing arm function. For example, both MBI, evaluating painless shoulder joint external rotation joint motion range, ability to perform everyday actions, and FM-U/E, evaluating degree of paralyzed arm function recovery, showed higher scores in the group with no pain. It can be seen that BPI-12 (>4.25 points), BPI-23 (>5.5 points) are important cutoff values for predicting motion disorder and activity level related to functional performance and shoulder joint pain of stroke patients adversely restricts arm movements and performance of daily living activities. Therefore, it is necessary to maintain a posture which can minimize shoulder joint pain after a stroke and improve the range of motion. In addition, emphasis should be placed on functional arm performance training which can improve pain-related life satisfaction.

According to the results of BPI-12 and 23 we propose NRS>4.25 points, and NRS>5.5 points as cutoff values for predicting shoulder pain in stroke patients. We consider they should be utilized as supplementary material for evaluating functional performance ability. Since this study investigated only patients who had no shoulder subluxation, we did not perform quantitative analysis of subluxation with X-rays, which may have results in bias in the HBN test. The BPI-12 and 23 surveys were self-administered, so the pain severity which the patients were conscious of was able to be differentiated, and individual differences in recognizing physical and functional performance ability served as negative factors of influence. There are diverse causes of stroke patients' shoulder pain, so, in further studies, it will be necessary to examine the causes of stroke patients' shoulder pain according to pathophysiology to investigate satisfaction with life related to the pain and its severity in diversified ways.

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