



# Walking speed affects instrumental activities of daily living in patients with hip osteoarthritis

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# 博士論文

Walking speed affects instrumental activities of daily living in patients with hip osteoarthritis

(変形性股関節症患者の歩行速度は手段的日常生活動作に影響する)

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**Title:** Walking speed affects instrumental activities of daily living in patients with hip osteoarthritis

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**Abstract**

**BACKGROUND:** The symptoms of hip osteoarthritis (OA) influence instrumental activities of daily living (IADL). Evidence from previous studies suggest that body functions and walking speed are important etiological factors for IADL. However, no studies have investigated which factors that have the greatest influence on IADL.

**OBJECTIVE:** The aims of this study were (1) to analyze factors related to IADL in patients with hip OA, including 10 m walking speed (10 mWS), and (2) to establish cut-off values for factors that predict maintenance of IADL.

**METHODS:** Forty-eight patients participated in this study. IADL was treated as dependent variable. Range of motion (ROM), muscle strength of the hips and knees, and 10 mWS were measured as independent variables. Other potential confounding factors were also measured. Data were analyzed using hierarchical multiple regression and Receiver Operating Characteristic curve analysis.

**RESULTS:** The hip flexion ROM on the affected side and 10 mWS were selected as significant variables in this study. The cut-off values obtained were 92.5 degrees for the hip flexion ROM on the affected side and 42.3 m/min for 10 mWS.

**CONCLUSIONS:** The suggested target associated with maintaining IADL in patients with hip OA is the cut-off value of 42.3 m/min for 10 mWS found in this study.

Key words: Instrumental activities of daily living; Osteoarthritis of the hip; Walking speed

## 1. Introduction

Osteoarthritis of the hip (hip OA) is a chronic musculoskeletal problem in elderly people, caused by joint degeneration. Previous studies indicated that the incidence of secondary hip OA in the general population was 1.0–2.4% in Japan, 10.1% in the U.K, and 4.7% in France, with a higher incidence in females than in males [1,2]. The symptoms of hip OA influence body functions and activities of daily life [3]. Cecchi et al. [4] clarified that patients complaining of hip pain were more likely to report disability in instrumental activities of daily living (IADL), such as shopping, carrying a bag, and using public transportation, thus life space in community was narrowed. Limited life space associates with further decline of IADL, and it influences quality of life (QOL) in elderly people [5,6]. Therefore, it is important for IADL to be assessed for patients with hip OA to help maintain their QOL during treatment and rehabilitation.

Although a few studies have reported the relationship between physical impairments and IADL, a systematic review of IADL for patients with hip OA indicated that the level of evidence for this was limited [7]. Physical impairments, including hip pain, reduced muscle strength, and restricted range of motion (ROM), are often observed in patients with hip OA. These have frequently been studied with regard to how they limit IADL [8,9]. On the other hand, walking speed is regarded as an important predictor of independent living in the community, along with other factors [6]. Hip OA is a disease associated with one of the fastest rates of decline in walking speed [10,11]. Donoghue et al. [12] investigated the effect of walking speed on IADL in 1,664 elderly subjects and suggested that walking speed was an effective measure for predicting disability in IADL. Fried et al. [13] also showed that IADL decreased in association with decreasing walking speed. It is assumed that walking speed similarly influences the limitation of IADL in patients with hip OA, possibly intervening between body functions and IADL. However, the relationship between walking speed and

IADL in patients with hip OA has not been previously reported. Moreover, the cut-off points for factors related to IADL are unclear. Clarifying this relationship and the cut-off points contribute to maintain IADL to plan effective rehabilitation programs including goal setting for patients with hip OA. Thus, it is potentially useful to analyze further the relationship between IADL and the factors, including walking speed.

The aims of the present study were to collectively examine factors related to IADL, including walking speed, in patients with hip OA and to clarify the cut-off points for the factors.

## **2. Methods**

### *2.1. Subjects*

This retrospective cross-sectional study was conducted in a hospital in Kurashiki City, Japan. Forty-eight women with hip OA who plan to undergo total hip arthroplasty (THA) participated in this study (age range, 50–86 years; mean, 69.2 years). Exclusion criteria included: previous THA and osteotomy of either hip, diagnosis of a neurological condition and knee problem. The average height was 150.2 cm (SD = 5.2) and weight was 53.4 (SD = 8.7). The hip OA in all the subjects at the time of radiographic diagnosis was classified as advanced stage and over according to the X-ray classification of the Japanese Orthopaedic Association (JOA).

### *2.2. Ethical considerations*

All the measured parameters were essential for assessing the subjects' functional status and were not harmful. All procedures were conducted in accordance with the World Medical Association Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects of 1975. The protocol, including consent procedures, was approved by the Research Ethics Committee of Kawasaki Medical School and Hospital (approval number 2163).

### *2.3. Procedures*

#### *2.3.1. Dependent variable*

IADL was treated as the dependent variable and measured using the Self-Rating Frenchay Activities Index (SR-FAI), an assessment tool for measuring IADL function originally developed for the assessment of stroke patients [14] and frequently used for elderly people who live in the community [15]. Its high levels of validity and reliability have been

demonstrated [16-18]. Pilot testing for hip OA confirmed the validity of this measurement. This tool measures activities that reflect a greater level of independence and social survival [19]. The SR-FAI comprises 15 items (preparing main meals, washing up, washing clothes, light housework, heavy housework, local shopping, social outings, walking outside, actively pursuing hobby, driving car/bus travel, outings/car rides, gardening, house/car maintenance, reading books, and gainful work), with each item scored from 0 (never or none) to 3 (daily or weekly), yielding a total score within the range 0 (no activity) to 45 (frequently participating in all the activities).

### *2.3.2. Independent variables*

Bilateral ROMs were measured for hip flexion, extension, and abduction, based on the method described by Norkin [20]. Each ROM was treated as an independent variable.

Bilateral muscle strengths were measured twice for hip flexion, extension, and abduction, and knee extension. Maximum muscle strength was assessed using a hand-held dynamometer ( $\mu$ Tas F1, ANIMA, Japan) with a fixed band during isometric contraction for 3 s. The force sensor was placed 5 cm proximal to the proximal edge of the patella border for hip flexion, 5 cm proximal to the knee joint line at the posterior thigh for hip extension, 5 cm above the lateral epicondyle of the femur for hip abduction, and 5 cm above the lateral malleolus for knee extension. Their lower limbs were set at straight for measuring hip extension and abduction. Torque was calculated by multiplying force by the lever arm (distance between the force sensor and the center of the groin for hip flexion strength, the ischial tuberosity for hip extension strength, the greater trochanter for hip abductor strength, or the level of the tibial plateau for knee extension strength) and expressed as a percentage of body weight (Nm/kg). The average values were used in the analyses. These methods have been demonstrated to show high reliability [21].



The preferred 10 m walking speed (10 mWS) was measured as a further independent variable, in a long corridor with an even surface from a standing start. Each measurement was conducted twice. The faster value was adopted in consideration of minimalizing measurement bias.

### *2.3.3. Confounding variables*

Each patient's age and body mass index (BMI) were recorded as potential confounding factors in the study, as were hip pain during walking, leg length discrepancy (LLD), affected side (unilateral or bilateral), Crowe classification, and severity of hip OA based on the X-ray classification of JOA. The affected side was defined as the operation side, whereas the unaffected side was defined at the opposite side. Pain was measured with the 10 cm Visual Analog Scale (VAS) [22], with no pain coded as 0, and extreme pain coded as 10. The subjects evaluated their own hip pain during walking. LLD, defined as the difference in mm in the perpendicular distance between a line passing through the lower edge of the teardrop points to the corresponding tip of the lesser trochanter, was measured by X-ray. The interclass correlation coefficient for this method was satisfactory [23].

The affected side, Crowe classification, and severity of hip OA were also identified using X-ray. Cases with bilateral affected side were coded as 1. The Crowe classification assesses the degree of deformity and dislocation of the hip joint [24], from least severe Crowe I dysplasia (coded as 0) to the most severe Crowe IV (coded as 3). Subjects classified with advanced stage hip OA were coded as 0 and with end-stage hip OA were coded as 1.

### *2.3.4. Data Analysis*

Pearson correlation coefficients were calculated to assess the relationship between SR-FAI score and the independent variables in this study. After assessing the multicollinearity of the

independent variables using correlation, potential predicting variables were entered into a hierarchical multiple regression model to determine the most accurate set of variables for the prediction of SR-FAI. Age, BMI, VAS, LLD, affected side, Crowe classification, and severity of hip OA were entered into this model as confounding factors.

Receiver Operating Characteristic (ROC) curve analysis was used to determine cut-off points for variables identified by multiple regression analysis to discriminate between high and low SR-FAI scores. Classification of SR-FAI was based on the standard value (27.5) for Japanese people aged between 70 and 79 years reported in a previous study [25]. SR-FAI  $\geq$  27.5 was coded as 1 and SR-FAI  $<$ 27.5 as 0. The value achieving the maximum sum of sensitivity and specificity was chosen to be the cut-off point and area under the curve (AUC) was also calculated. The software package SPSS ver. 19.0 (SPSS, Chicago, IL) was used for the statistical analyses, and the significance level was set at  $P < 0.05$ .

### 3. Results

Mean values for the measured variables are presented in Table 1. ROM of hip flexion on the affected side, bilateral ROM of hip extension, muscle strength of hip extension and abduction on the unaffected side, muscle strength of knee extension on the affected side, and 10 mWS were all significantly correlated with SR-FAI (Table 2). Hierarchical multiple regression analysis was used to identify the variables associated with SR-FAI. In the final model, 10 mWS ( $\beta = 0.378$ ) and ROM of hip flexion on the affected side ( $\beta = 0.324$ ) were selected as significant variables (table 3). All the variance inflation factors were between 1.211 and 1.861 and it was judged that there was no significant multicollinearity.

ROC curve analysis was performed for the two variables identified by the multiple regression analysis (Figure 1,2): 10 mWS and ROM of hip flexion on the affected side. From this analysis, the cut-off point for 10 mWS was 42.3 m/min (sensitivity 89.4%, specificity 51.7% with AUC of 0.67), and the cut-off point for ROM of hip flexion on the affected side was 92.5 degrees (sensitivity 42.1%, specificity 86.2% with AUC of 0.61).

## 4. Discussion

### 4.1. IADL scores in patients with hip OA

In this study, the mean value of the SR-FAI score was 25.0. This value was higher than for patients with, for example, subacute myelo-optico-neuropathy and systemic lupus erythematosus, but was lower than for patients with lung cancer or females of the same age [25-28]. In general, SR-FAI in the elderly tends to decline with age, but in this study SR-FAI was not significantly related with age. This suggests that hip OA has limited the subjects' ability for IADL, irrespective of age.

A previous study of Japanese females established mean values for each item in SR-FAI [25]. Some of these results were similar to those in the present study, such as 2.3 for "Preparing main meals," 2.6 for "Washing up," 2.6 for "Washing clothes," and 2.6 for "Light housework". However, the previous study found the mean "Heavy housework" score to be 2.4, whereas in the present study it was only 1.3. This suggests that although patients with hip OA may be able to do brief domestic chores to a similar extent to other females of the same age, their ability to perform "Heavy housework," such as carrying something, is limited. Similarly, there was a close match between the two studies in their scores for "Local shopping" (2.5), but the previous study's mean scores for "Walking outside" (2.5), and "Driving car/bus travel" (1.8) were higher than those found in the present study (2.0 and 0.5, respectively), suggesting that activities beyond "Local shopping" that involve going out into the neighborhood tended to be limited for patients with hip OA.

### 4.2. Relationship between IADL and ROM of hip flexion

ROM of hip flexion on the affected side was selected as a significant value independent of the confounding factors and 10 mWS to predict SR-FAI. A previous study [8] showed that ROM of hip flexion correlated with the scores from WOMAC (Western Ontario and

McMasters Universities Arthritis Index), but no previous study has identified a significant relationship between physical impairments and IADL with these confounding factors into consideration.

The reason why hip flexion ROM on the affected side was selected as a significant predictor in the present study is that adequate ROM may be essential for performing IADL. For example, hip flexion is important for daily activities such as sitting on a chair or on the floor to accomplish IADL, particularly for elderly Japanese people who still prefer the floor for most of their activities of daily living. Mulholland et al. [29], in their investigation in Asian countries of ROM of the hip necessary for movement on the floor, indicated that a mean hip flexion ROM of 110 degrees was required for sitting cross-legged, and 130 degrees for the squat position.

Although the evidence grade was limited, a few previous studies using randomized control trials have shown that exercise therapy could maintain ROM in patients with hip OA [30,31]. However, the previous studies lacked a concrete guideline on the amount of ROM to aim for to produce the required outcome. In the present study, the cut-off value for ROM of hip flexion to maintain IADL, calculated using the mean value of SR-FAI of women of the same age, was 92.5 degrees. It is consequently suggested that the IADL ability of patients with hip OA may be maintained by keeping their ROM greater than this cut-off angle; this result contributes to the establishment of a rehabilitation goal.

#### *4.3. Relationship between IADL and walking speed*

The mean value of 10 mWS in the present study was 47.9 m/min, lower than the mean value of females of the same age reported in a previous study [32]. Walking speed in the elderly generally tends to decrease with age, but in the present study, 10 mWS was a predictor of SR-FAI independent of age. According to a study in which 72 patients with hip OA were

interviewed, the main reason why patients wanted to undergo THA was pain in the daytime and difficulty walking [33]. Consequently, the expectation was high that THA would result in improvement to their walking, and thus, the role of effective physical therapy intervention after THA was believed to be important.

In this study, increase in 10 mWS positively influences IADL. Although 10 mWS is a simple test measuring only walking speed on short distance, it can be able to expect ability of long distance walking [34]. In addition, Shimada et al. [35] reported that walking speed was significantly associated with life-space restriction. Thus, it is considered that patients with high 10 mWS have less restriction in their sphere of activities. Moreover, assessing life space reflects the participation in social activities, including transportation difficulty [36]. Therefore, 10 mWS may relate to IADL in the present study.

In correlation analysis relating SR-FAI and the independent variables, significant Pearson correlation coefficients were obtained for ROM of hip flexion on the affected side, bilateral ROM hip extension, muscle strength of hip extension and abduction on the unaffected side, and muscle strength of knee extension on the affected side, supporting the results of a previous study [8]. However, in the hierarchical multiple regression analysis that included 10 mWS, all the muscle strength variables were not selected as significant variables, although the previous study reported that muscle strength of knee extension was a predictor of IADL. The reason why all the muscle strength variables were not selected as significant variables in the present study may be due to the different method of statistical analysis performed, which included confounding factors and 10 mWS as an intervention factor. Muscle strength may not have been a significant predictor of SR-FAI in this study because it correlated with 10 mWS, as was shown by Lin et al. [3] who reported a relationship between muscle strength and walking speed. Thus, it is possible that 10 mWS intervenes between body functions such as ROM, muscle strength, and SR-FAI.

Fukumoto et al. [37] showed that walking speed was improved by muscle strengthening exercise, and exercise therapy from a physical therapist has been recommended in the guidelines of Osteoarthritis Research International [38]. It is suggested that a target point for 10 mWS which contributes to maintenance of IADL in patients with Hip OA is the cut-off value of 42.3 m/min established in this study. As the accuracy of cut-off point for 10mWS was higher than that of ROM of hip flexion, the value of 10mWS is particularly necessary to be evaluated for maintaining IADL in patients with hip OA.

#### *4.4. Limitations*

The small sample size would increase the probability of committing type II error, thus factors that had not been identified as significant predictors in the present study such as severity of hip OA could be associated factors for SR-FAI in future study with a larger sample size.

Social background, upper extremity and trunk functions, as well as psychophysiological factors, which have previously been indicated to be factors associated with IADL, were not included in the present study. As the results of the low accuracy for both 10mWS and ROM of hip, it might be possibility that other factors relate to IADL. Therefore, future research need to evaluate these factors and it is necessary to confirm whether factors selected in present study will be selected as significant variables among these factors.

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Table 1. Values of the measured variables (N = 48)

Age, mean (SD)		69.2 (10.0)
Height (cm), mean (SD)		150.2 (5.2)
Weight (kg), mean (SD)		53.4 (8.7)
BMI (kg/m <sup>2</sup> ), mean (SD)		23.6 (3.5)
VAS (mm), mean (SD)		34.4 (24.7)
LLD (mm), mean (SD)		14.3 (13.5)
ROM of hip (°), unaffected side, mean (SD)	flexion	100.9 (15.3)
	extension	13.1 (6.6)
	abduction	30.4 (9.9)
ROM of hip (°), affected side, mean (SD)	flexion	79.2 (18.9)
	extension	5.3 (9.3)
	abduction	16.6 (8.5)
Muscle strength of hip (Nm/kg), unaffected side, mean (SD)	flexion	0.50 (0.17)
	extension	0.39 (0.14)
	abduction	0.48 (0.19)
Muscle strength of hip (Nm/kg), affected side, mean (SD)	flexion	0.36 (0.17)
	extension	0.27 (0.15)
	abduction	0.37 (0.19)
Muscle strength of knee (Nm/kg), unaffected side, mean (SD)	extension	0.86 (0.29)
Muscle strength of knee (Nm/kg), affected side, mean (SD)	extension	0.65 (0.27)
10mWS (m/min), mean (SD)		47.9 (14.9)
Crowe classification, <i>n</i>		I :36 II :6 III :3 IV :3
Affected side, unilateral, <i>n</i> (%)		36 (75)
Severity of Hip OA based on JOA, advanced stage, <i>n</i> (%)		10 (21)
SR-FAI (point), mean (SD)	Total	25.0 (7.2)
	Preparing main meals	2.6 (0.9)
	Washing up	2.6 (0.9)
	Washing clothes	2.6 (0.8)
	Light housework	2.4 (1.0)
	Heavy housework	1.3 (1.2)
	Local shopping	2.4 (1.0)
	Social outings	1.7 (1.0)
	Walking outside	2.0 (1.1)
	Actively pursuing hobby	1.5 (1.3)
	Driving car/bus travel	0.5 (0.7)
	Outings/car rides	2.4 (1.1)
	Gardening	0.7 (1.0)
House/car maintenance	0.3 (0.8)	
Reading books	1.3 (1.2)	
Gainful work	0.6 (1.2)	

*n*, number; SD, standard deviation; BMI, body mass index; VAS, visual analogue scale; LLD, leg length discrepancy; ROM, range of motion; 10mWS, 10 m walking speed; JOA, Japanese Orthopaedic Association; SR-FAI, Self-Rating Frenchay Activities index.

Table 2. Pearson coefficients for correlations between SR-FAI and other variables

		correlation coefficient (r)	P value
Age		-0.13	0.39
BMI		0.11	0.47
VAS		-0.17	0.26
LLD		0.07	0.62
ROM of hip, unaffected side	flexion	0.22	0.14
	extension	0.29	0.04
	abduction	0.17	0.25
ROM of hip, affected side	flexion	0.36	0.01
	extension	0.33	0.02
	abduction	0.07	0.62
Muscle strength of hip, unaffected side	flexion	0.26	0.08
	extension	0.33	0.02
	abduction	0.31	0.04
Muscle strength of hip, affected side	flexion	0.28	0.06
	extension	0.20	0.17
	abduction	0.15	0.29
Muscle strength of knee, unaffected side	extension	0.20	0.17
Muscle strength of knee, affected side	extension	0.31	0.03
10mWS		0.44	0.01

BMI, body mass index; VAS, visual analogue scale; LLD, leg length discrepancy; ROM, range of motion; 10mWS, 10 m walking speed.

Table 3. Results from hierarchical multiple regression analysis

Dependent value	Independent value	$\beta$	P value	ANOVA	$R^2$
SR-FAI				p<0.05	0.21
	10mWS	0.378	0.019		
	ROM of hip flex, affected side	0.324	0.035		
	Severity of hip OA	0.260	0.082		
	VAS	-0.118	0.439		
	Affected side	-0.117	0.472		
	Age	-0.077	0.637		
	Crowe clasification	-0.068	0.693		
	BMI	-0.067	0.641		
	LLD	-0.011	0.950		

$\beta$ , standardized partial regression coefficient; ANOVA, analysis of variance;  $R^2$ , multiple correlation coefficient adjusted for the degrees of freedom; SR-FAI, Self-Rating Frenchay Activities index; BMI, body mass index; VAS, visual analogue scale; LLD, leg length discrepancy; ROM, range of motion; 10mWS, 10 m walking speed.



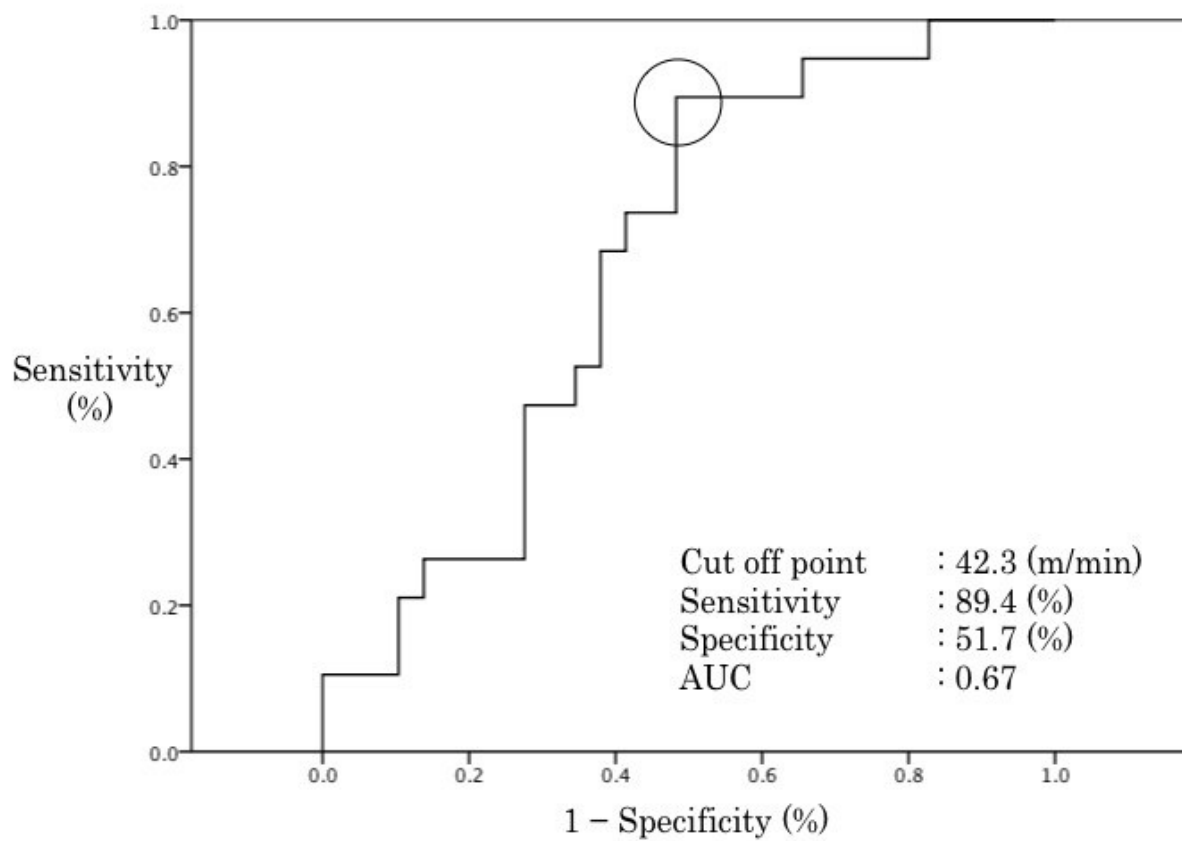


Figure 1. ROC analysis for 10 m walking speed

AUC, area under the curve

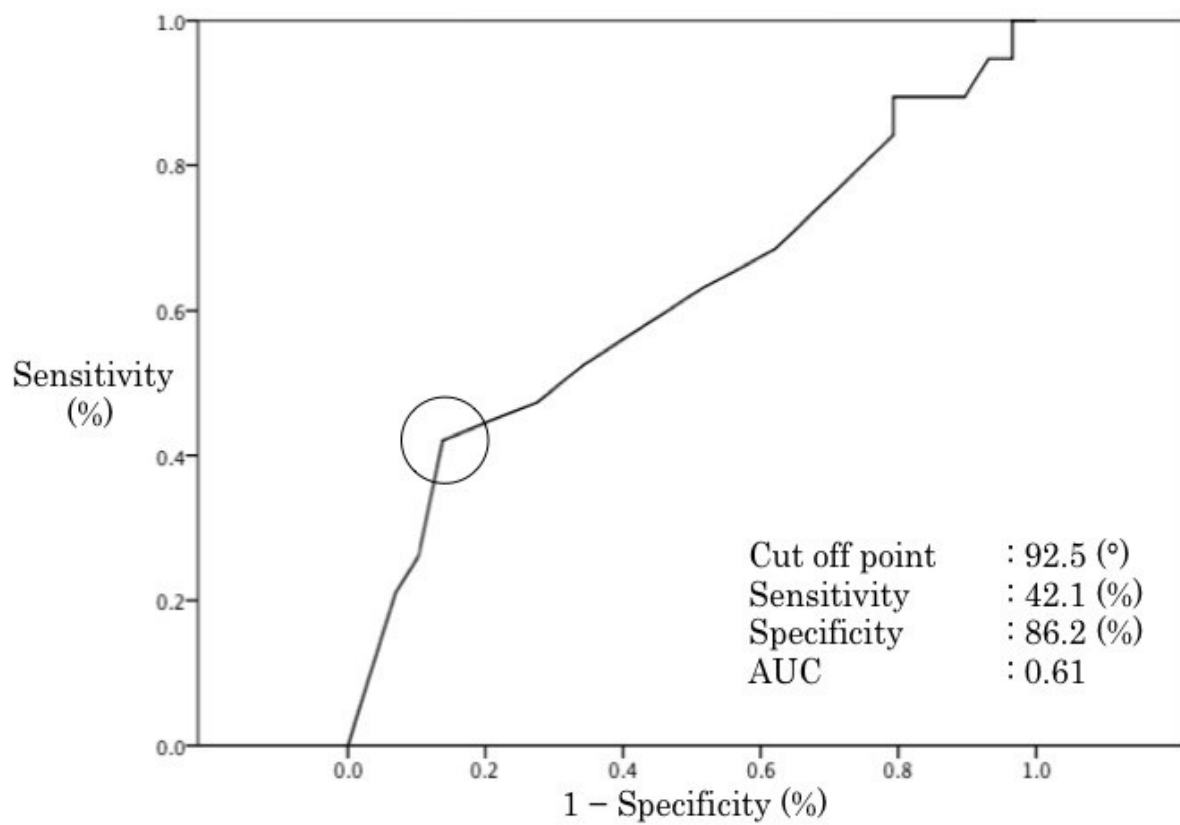


Figure 2. ROC analysis for ROM of hip flexion on the affected side

AUC, area under the curve