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뇌졸중 환자의 운전재활 시기 결정을 위한 K-MBI의 임상적 유용성: 예비 연구

Clinical Usefulness on K-MBI for Decision of Driving Rehabilitation Period in Patients with Stroke: A pilot study

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ABSTRACT

Background & Object: Basic daily activity screening tool such as the Modified Barthel Index (MBI) has been used commonly in rehabilitation clinic and community based rehabilitation setting. Previous studies have shown the significant relations between the level of daily activities and driving ability on stroke or elderly people. However, there is a lack of studies to investigate the usefulness of MBI on prediction of driving ability for stroke patient. This study was to predict driving abilities of stroke survivor using Korean version Modified Barthel Index (K-MBI). Methods: A sample of 48 patients with stroke in rehabilitation hospital was recruited. All participants were tested level of basic daily activities using K-MBI. The driving ability of participants was tested using virtual reality driving simulator. The predictive validity was calculated of the K-MBI among pass or fail group of driving simulator test using receiver operating characteristics curves. Results: The cut-off score of >86.5 on the K-MBI is proper sensitivity to predict on driving performance ability. Conclusion: This pilot result offers clinical reference to therapists and caregivers for reasoning on driving recommendation period during rehabilitation stage of stroke survivors. Further studies need to identify prediction using real on-road test in a large population group.

요 약

연구배경 및 목적: 수정된 바델지수(MBI)는 지역사회 재활세팅 및 재활 병원에서 흔히 사용되어지는 기본적인 일상생활 평가 도구이다. 선행 연구들에 의하면 노인 혹은 뇌졸중 환자들의 운전 능력과 일상생활활동의 수준은 유의미한 상관성이 있음을 보고된 바 있다. 그러나, 뇌졸중 환자의 운전능력을 예측함에 있어 임상에서 흔히 사용되는 일상생활 활동 기본 평가인 수정된 바델지수의 유용성을 밝힌 연구는 미비하다. 본 연구에서는 한국형 수정된 바델 지수(K-MBI)룰 활용하여 뇌졸중 환자의 운전 가능성을 알아봄으로서 운전 수행 능력을 예측함에 있어 한국형 수정된 바델 지수의 임상적 유용성을 알아보고자 하였다. 연구방법: 서울 소재 재활병원에서 재활치료를 받고 있는 뇌졸중 환자 48명이 연구에 참여하였다. 모든 연구 대상자에게 K-MBI 검사를 통해 기본적인 일상생활 활동 수준을 측정하였고 가상현실 운전시뮬레이터를 이용하여 운전 수행능력을 측정하였다. 운전 시뮬레이터상의 운전 수행 검사의 합격/불합격에 따른 K-MBI 점수의 예측 타당도를 ROC curve를 이용하여 검증하였다. 결과: 뇌졸중 이후 운전재활을 권고할 만한 기본적인 일상생활 활동 수준은 K-MBI 점수가 최소 86.5점인 경우가 적절한 것으로 나타났다. 결론: 본 연구는 뇌졸중 환자의 운전 재활을 권고하는 시기를 예측함에 있어 유용한 기초 자료가 될 것으로 판단된다.

Keywords : Clinical usefulness, Driving rehabilitation, K-MBI, Period, Stroke

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1. Introduction

1.1 Background and Object

Many people with neurological damage such as stroke patients not only have a bad motor control but also they have poor visual, perceptual and cognitive function[1]. Therefore, stroke survivors often suffer due to motor, visual, and cognitive problems that might difficult their driving performance[2]. According to the International Classification of Functioning (ICF), driving belongs to the mobility domain of daily activities[3-4]. Rehabilitation specialists aid to live independently their client through specific training. Especially, occupational therapists make a goal to return to their society for disabled person and elderly in driving rehabilitation areas through using fitness driving evaluation and training[5-6]. Stroke survivors with self‐driving skills can have more chance to the social participation than others and they can possible to lead various occupation such as shopping, enjoying hobbies, maintaining economic activities[7-8]. Therefore, returning to driving is a main concern for stroke patients and their caregivers. However, driving is very complicated occupation that requires various functional abilities. In generally, for performing to safety drive need to excellent motor, vision, perception and cognitive functions[9]. For example, for turning the wheel and pushing the foot pedals, stroke survivors have to have motor functions such as good motor coordination, suitable postural control and range of motion of upper and lower extremities. Also, for recognizing traffic signs and keeping between lines, they must be able to keep accuracy visual-perceptual functions and they need to cognitive functions for such as anticipating speed limit and planning safety in merging when driving[10-11]. In various previous studies were showed importance to improve of functions after stroke for driving. And according to previous study, about 30-60% of stroke survivors resume to the driving[12-13]. Also, For patients who resumed driving after the onset of stroke, it has been reported that there is a high rate of participation in the local community[14]. Thus, for the stroke survivors, in order to accomplish more independent qualitative life, self-driving ability is speculation as the main factor. That means it is important to provide a specific service as driving rehabilitation. However, it is difficult to decision proper period for administration of driving rehabilitation after admission at hospital for our clients. Almost, it is followed opinions of doctor and therapist based on their clinical experience or clients' need when we try to specific evaluation and training for returning of driving.

In order to perform an evaluation that can predict whether or not to resume driving of the patient, therapist apply several physical, visual-perceptual, cognitive evaluation such as Useful Field of View (UFOV), Motor-free Visual Perception Test (MVPT), Trail Making Test A & B (TMT A&B), Optical Vision Test and driving simulation. These assessments are using among specific tools for prediction of driving ability and our clients have to pay more costs and times for receiving specific evaluation[15-17]. Therefore, these specific evaluations have to application beyond on clients' agreement for driving rehabilitation.

However, therapists can recommendation driving rehabilitation by their clinical reasoning[18]. For this recommendation, therapist have to find just-right period in the recovery stage of their patients through using simple and quick screening test such as Modified Barthel Index or Mini-Mental Status Examination[19]. Because these evaluations are commonly used in clinical setting. Especially, Modified Barthel Index is very useful test for screening on basic activity functions of our clients[9]. Even through, Modified Barthel index is not specific tool to measure driving skills, it provides information for therapist to know client's general functions in the daily living. It is foundation to make decision clinical reasoning about their client's functions. When the therapist recommend about the driving rehabilitation to their clients, if it can be provide right-period for driving training, it is very useful to help for therapist's decision making although it is not specific measurement for driving.

Therefore, this study aimed to know cut-off score of Korean version Modified Barthel Index (K-MBI) to decide a suitable point for recommendation of driving rehabilitation for stroke patients.

2. Methods

2.1 Participants

This study was a cross-sectional design and a total of 48 stroke patients participated in the study. The participants were recruited from among patient being admitted at a rehabilitation hospital in Seoul. The sampling was used convenience method. All participants were diagnosed as having stroke. The inclusion criteria as follows: (a) patients that had over 6 months from onset, (b) patient that had each over level 4 in Brunnstrom recovery stage of upper extremity and lower extremity and (c) patients that had self-driving experience at least 1 year before onset. Patients were excluded from the study if they were unable to perform driving simulator due to visual or auditory impairments. This study was approved by local ethics committee and the chief of study explained to participants about the purpose and methods, procedure and ethical issue based on the Declaration of Helsinki[20]

2.2 Measurements

2.2.1 Korean version Modified Barthel Index

The K-MBI was used to measure basic status in activities of daily living of participant. The original version of Barthel Index was developed by Shah and Cooper at 1993[21]. The K-MBI developed by Jung et al. Development process as follows: Six senior physiatrists translated the 5th version MBI into K-MBI. Fifteen different examiners working at the five different university hospitals evaluated video-recorded examination cases independently to test the reliability and validity of K-MBI. K-MBI was composed 10 item such as personal hygine, bathing, feeding, toileting, starling, dressing, bowl and bladder control et al. Each item was evaluated by 5 points Likert scale among patients' independence and total score is 100 points. According to the previous study this tool's inter-rater reliability was showed .90-.98 [22].

2.2.2 Virtual Reality Driving Simulator

To evaluate for driving abilities of participants, driving simulator was used. Driving simulator was used the GDS-300 that developed by Gridspace (Seoul, Korea, Figure 1). Software in the driving simulator was composed of two domains: driving aptitude tests, on-road course tests. Driving aptitude tests are assessment for essential driving ability based on motor and cognitive function for safe driving and it is consist of four sub-items: reaction time, judgment, speed anticipant and steering wheel-pedal operation test. Also, on-road course tests in the simulator were composed of various road course scenarios. In this study, specific two courses: exercise mode & test mode were used for evaluating driving ability. The test course was used scenario from the downtown in Seoul to highway driving. The Software in the driving simulator system checked the driving errors when the participant drives in the road course test. In the items of driving errors included failed to use seat belt, exceeded speed limit, turn signal errors, crossed central line, accidents. When the participant evoked driving errors, the score was as low. The scores of each item were 10 points and the total score was 100 points. The total score should be represents more than 70 points, the result is interpreted the pass [16].

2.3 Procedures

An occupational therapist assessed all of the participants. First, the occupational therapist assessed basic activities of daily living status of participants using K-MBI. And then, there were checked driving performance ability using the simulator.

그림 1. 운전 시뮬레이터
Fig. 1. Driving simulator

To minimized misusing errors of driving simulator for participants had practice using exercise mode in the simulator before test mode. In the test mode, all of the participants drove same test course.

2.4 Data Analysis

Descriptive statistics were used to describe the demographic characteristics of all the participants. The Chi-square test and the independent t-test were used to compare the demographic characteristics and functional performance ability between pass and fail group in the driving test results.

The receiver operation characteristic curve (ROC), sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were analyzed to know the cutoff-value between the K-MBI scores and the driving ability score. All data analyzed using the IBM SPSS software version 20.0 for Window (IBM SPSS Inc., Chicago, IL, USA) and the level of significance was set at $p < .05$.

3. Results

3.1 Demographic characteristics of participants

Of the 48 participants, the mean age was 47.68 years (standard deviation [SD]: 12.69), the mean driving experience was 15.22 years [SD]: 8.28) and the mean K-MBI score 78.04 points [SD]: 18.90). All of the participants were mainly male (72.9%) and the rate of hemiplegic side was similarly between right side (47.9%) and left (52.1%). The demographic characteristics of all participants are summarized in Table 1. The chi-square test showed significant difference between pass and fail group among driving test result in the gender or hemispheric side ($p < .05$). The results of the independent t-test indicated that there were no significant difference in the age or driving experience among driving test result ($p > .05$). However, significant difference was showed in the K-MBI total score between pass and fail group of driving result ($p < 0.5$) (Table 2).

3.2 Cut-off value of K-MBI, Sensitivity, Specificity, PPV and NPV

The cut-off score of K-MBI in the pass or fail group of driving test was 86.50 points. The sensitivity was 0.60 and specificity was 0.61 (Table 3). The area under the ROC curve (AUC) was acceptable level as 0.71 (95% CI 0.56 - 0.86) (Figure 2). The PPV was showed 68.0% while the NPV was lower, 52.17%. In other words, the PPV of the K-MBI indicated that the 25 participants who received a lower score (≤ 86.5), 17 (68.0%) failed the driving test. Of the 23 participants who received a score of > 86.5 on K-MBI result, only 12 passed driving test, resulting in a NPV of 52.0 % (Table 4).

표 1. 연구 참여자들의 일반적인 특성

Table 1. Demographic characteristics of all participants (N=48)

Variables		Values
Gender		
	Male	35 (72.90)
	Female	13 (27.10)
Age (year)		47.68±12.69
Driving experience (year)		15.22±8.28
Hemiplegic side		
	Lt	23 (47.90%)
	Rt	25 (52.10%)
K-MBI total score		78.04±18.90

Note: Value represent Mean±SD and frequencies (%)

표 2. 운전 수행 검사의 합격군과 불합격군 사이의 특성 비교

Table 2. Characteristics comparison between pass and fail group of driving test

		Pass group (n=20)	Fail group (n=28)	t/ x^2	p
Gender	Male	18(51.40)	17(48.60)	5.06	0.02*
	Female	2(15.40)	11(84.60)		
Age(year)		48.55±14.51	45.35±11.03	0.85	0.39
Driving experience (year)		15.85±8.46	14.78±8.27	0.43	0.66
Hemiplegic side	Lt	14(60.90)	9(39.10)	6.70	0.01*
	Rt	6(24.00)	19(76.00)		
K-MBI total score		85.35±14.53	72.82±20.13	2.37	0.02*

Note: Value represent Mean±SD and frequencies (%)
*Significant difference $p < 0.05$

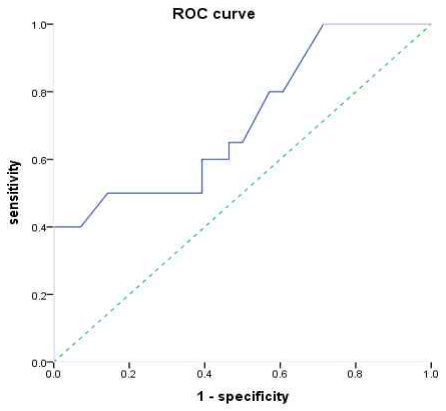

그림 2. 운전 수행검사의 합격과 불합격을 예측하기 위한 K-MBI의 절단점 및 ROC 커브

Fig. 2. ROC Curve of total sample with cut-off point based on K-MBI score predicting pass and fail of driving test

표 3. K-MBI의 절단값, AUC, 민감도 및 특이도

Table 3. The cuff-off value, AUC, Sensitivity and specificity of K-MBI (N=48)

	Cut-off value	AUC(95% CI)	Sensitivity	Specificity	p
K-MBI	≤86.50	0.71(0.56-0.86)	0.60	0.60	0.01

Note: AUC is the area under the ROC curve, CI is confidence interval

표 4. 운전 수행 검사 결과에 따른 K-MBI 절단값의 양성예측도와 음성예측도

Table 4. PPV and NPV of the cut-off value of K-MBI among driving test result (N=48)

K-MBI cut-off score	Driving test result		
	Fail group	Pass group	Total
≤86.5	17	8	25
>86.5	11	12	23
Total	28	20	48
PPV: 68.0 %, NPV: 52.17%			

Note: PPV is positive predictive value, NPV is negative predictive value

4. Discussion

Specialist in the rehabilitation helps their clients using various rehabilitation training and they establish the goal in order to living independently with residual functions. Especially, driving rehabilitation specialists focus on client's occupations in the daily living and one of them is self-driving[23]. In most cases, whether their client resuming driving after a stroke it depends on the clinical reasoning of the occupational therapist. In this study, using the K-MBI, which is most commonly used in the clinical order to examine the training point of driving ability to perform post-stroke, it was you want to select a sorting reference value by executing the operation acceptance. Of the more patient 6 months after stroke onset, after measuring the current K-MBI score was judged whether the operation or performance acceptance with driving simulator. The results to analyze whether pass reference point to operation run through the curve of the ROC curve, was the cut-off score when K-MBI score is 86.50 points. In this case, the under area of ROC curve is shown in 0.71 above. According to Greiner and collage's study, the area of under the ROC curve is classified as follows : 0.5 <AUC <0.7 ; the less exact, 0.7 <ACU ≤0.9 ; moderate exact, 0.9<AUC<1= ; very accurate and ACU = 1 ; very perfect inspection[24]. Thus, the results of the under area of ROC curve in this study was shown in the level of moderate to accommodate at 0.71. The positive and negative predictive values between the passing or failing of driving test were calculated using cut-off score follow as : between 86.5 excess group and 86.5 or less groups of K-MBI score. It was exhibited that the positive predictive value is 68% and the negative predictive value is 52%. These results indicate that, the K-MBI performed better as predictors of those who failed than of those who passed in driving test. Lower score on the K-MBI was indicated to be high predictive of failure on the driving test. This finding are that a cutoff of ≤86.5 on the K-MBI can appeared, with a fair degree of validity, failure in the driving test. According to the previous research, to take advantage of the K-MBI, which is an index of activities of daily life, when compared with preceding examined the relationship between the driving ability to conduct research, the operation and resume Barthel Index score showed a correlations. Especially, people who physical and cognitive deficits after stroke showed having less driving opportunity [2, 16]. Another previous study was showed that the co-relationship between driving ability and level of daily activities in community elderly[25-26].

Progressive changes of physical and cognitive condition due to aging were evoked driving errors in older people. As their daily activities scores were higher, driving performance skills were appeared more higher in older driver[27]. The results of this study, when the K-MBI score was showed upwards of than 86.5, participants successful drove on simulator. In other words, this result means when therapists whom in the rehabilitative hospital suggest training for driving to their patient with stroke, the appropriative period is predicted among upward of 86.5 at K-MBI score of client. In spite of this result, this study has some limitation. Because this study was preliminary research, the further study will have to progress using cohort design through large group. In this the study was used virtual reality simulator for measuring client's driving ability. It is best to measure the driving performance using on-road test because it represent real driving situation[27-28]. However, various studies were used driving simulator to measure driving performance like as STISM[28]. Because on-road testing has some limitation on safety in dangerous situations[29]. However, there is a study that the driving errors on the driving simulator is different with on-road driving performance. Therefore, next study will be have to investigate on-road conditions. In addition, in this study was showed the significant mean difference on driving performance between men and women. This result is similar the previous study that the women older has lower self-regulation on driving performance than the men[30-31]. Considering this fact, it is necessary to investigate whether there is a difference between driving performance and cut-off score of K-MBI by gender. Despite some limitations, this study has some clinical significance. This study provided the cut-off value of K-MBI score to predict driving skill of patient with stroke. It means K-MBI is usefulness to anticipate passing or failing value of driving ability. Also, it was showed possibility to help when therapist have to decision for clinical reasoning to recommendation driving resuming.

5. Conclusion

This study established the predictive validity of the K-MBI for measuring driving ability of patient with stroke. Although, K-MBI is a screening tool to measure for basic daily activities, its accuracy in predicting driving ability is closure to moderate exact. Clinically, this findings means when the therapists recommend driving rehabilitation to their client, the right period is 86.5 point of K-MBI scores. Even though, this study is pilot research, it provide evidence of clinical reasoning using K-MBI as widely used test for right period to recommend driving rehabilitation of stroke survivors in clinical setting.

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