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Special Review
Functional Assessment in Neurorehabilitation

Assessment of Upper Extremity Function in People With Stroke Based on the Framework of the ICF: A Narrative Review

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HIGHLIGHTS

- This review contains overview of upper extremity assessment according to International Classification on Functioning, Disability and Health framework.
- We provide information about the availability in Korean version of the test.

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ABSTRACT

Although there are many assessment tools for upper extremity (UE) function, it is still difficult to select an appropriate outcome measurement for the rehabilitation process of individuals with stroke. This review aims to classify each tool within the International Classification of Functioning, Disability and Health (ICF) framework and provide an overview of UE assessments. Through a comprehensive understanding of assessments based on ICF, health care professionals will be able to choose suitable measurement tools for individuals, facilitating their rehabilitation.

Keywords: Stroke; Outcome Assessment; Upper Extremities; Rehabilitation; Stroke Rehabilitation

INTRODUCTION

The comprehensive functional assessment of the upper extremity (UE) is important in both clinical and research settings, since it allows an in-depth understanding of individuals' function, rather than of the disease per se, and facilitates setting appropriate goals, planning interventions based on function, and tracking progress [1]. Numerous assessments of the UE have been developed and evaluated in terms of reliability and validity; nonetheless, it remains difficult to choose the most suitable outcome measure for individuals [2].

The International Classification of Functioning, Disability and Health (ICF), which is established by the World Health Organization (WHO), classifies human functioning and disability rather than disease, which is the role of the International Classification of Diseases. Outcome measures can be categorized into three ICF domains: body functions/structures, activities, and participation [3]. Referring to a previous systematic review that identified the most frequently cited UE measures in stroke [2], thirteen outcome measures were chosen for this study. The present review aims to provide an overview of UE functional assessments and categorize each measure within the ICF framework.

IMPAIRMENT (BODY FUNCTIONS AND BODY STRUCTURES)

According to the WHO [3], body functions are defined as "the physiological functions of body systems (including psychological functions)" (p.49). Impairment means having troubles in body function or structure due to an abnormal condition or critical injuries. Most standardized assessments quantify the extent to which the body function and structure are impaired [3].

Fugl-Meyer Assessment (FMA)

The FMA is the most commonly used tool in the field of stroke rehabilitation to measure overall motor impairment [4]. It follows the concept of recovery stages among people with stroke, which originated from Twitchell and Brunnstrom [5,6]. It measures the isolated joint control ability, which is hampered by synergies, as well as muscle strength, with a hypothesized ranked ordering of difficulty. This assessment is composed of five components: motor function, balance, sensory function, joint range of motion (ROM), and joint pain [7]. At present, only the motor function domain of the FMA is commonly measured, but not other components. The upper and lower extremity section of the FMA are frequently administered separately, and the entire assessment takes around 30–35 minutes to conduct [8]. The FMA-UE is divided into total, proximal, and distal parts, and these subtests are examined separately to detect the movement of body components because the authors suggested that each part of the UE recovers independently. The FMA has also shown excellent inter- and intra-rater reliability, as well as construct validity. Furthermore, the FMA is applicable to every recovery stage from acute to chronic [9]. The minimal clinically important difference (MCID) of the FMA-UE depends on the level of impairment; in those with minimal to moderate chronic stroke, it is 5.25 points, while in those with moderate to severe subacute stroke, it has a range from 4.9 to 12.4 depending on the body part of the UE: 12.4 for the upper limb, 5.6 for the upper arm, and 4.9 for the wrist/hand [10,11]. Furthermore, for those with severe subacute stroke, the MCID is 9 to 10 [12].

To cover both the domains of body function/structures and activity/participation in the ICF model, the FMA is utilized with other measurements of activity/participation such as the Action Research Arm Test (ARAT), Wolf Motor Function Test (WMFT), and Motor Activity Log (MAL). The most commonly used combination in research is the ARAT and FMA [13]. Although special training or certificates to administer the FMA are not necessary, See and Dodakian [14] provided a standardized training on the FMA in order to improve the accuracy of clinical assessments and maximize its use. Kim and Hwang [15] recently developed the Korean version of the FMA with a standardized training manual and demonstrated its reliability and validity. It is posted on the website of the University of Gothenburg (https://www.gu.se/en/neuroscience-physiology/fugl-meyer-assessment) along with versions in other languages [14].

Kinematics/Kinetics

Several studies have indicated that kinematic/kinetic parameters are classified into the body function and structure domain in the ICF [16-18]. Kinematic/kinetic assessments are needed for objective and sensitive measurements of UE movement and to distinguish true recovery (or restitution) from behavioral compensation [18]. Kwakkel et al. [18] established a standardized assessment of the quality of UE movements in stroke patients. They recommended that 2-dimensional kinematic assessments such as planar reaching tasks and finger individuation should be carried out on both the affected and the less affected arms at 1, 12, and 26 weeks after stroke onset, and at least 15 times per target in order to obtain accurate, reliable, and valid statistics. Furthermore, they explained a detailed assessment

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protocol, including appropriate postures and the measurement method for the standardized assessment. Along with the FMA, kinematic assessments have been increasingly used in research [13], and the rapid development of sensing technologies may accelerate kinematic and kinetic assessments to capture changes in body function/structure more sensitively.

ACTIVITY

Activity is defined as "the execution of a task or action by an individual" p.127. Activity limitations can be termed as a condition in which individuals have trouble carrying out activities [3].

ARAT

The ARAT was designed to assess arm motor function in terms of movement quality. It observes 19 items, containing four categories of functional movement (grip, grasp, pinch, and gross movements) on a 4-point scale, from 0 (no movement) to 3 (the movement is performed normally). A strength of this assessment is that the items in each subscale are organized in descending order of difficulty; in other words, it allows individuals to perform the most difficult task first, consequently enabling the prediction of success with the next items and thereby improving the efficiency of the assessment. As a result, the time for administration is about 5–15 minutes in total, depending on the number of items performed [19]. The intra-and inter-rater reliability of the ARAT was demonstrated to be high (intraclass correlation coefficient [ICC] > 0.098), and ARAT scores were proven to be closely correlated with other UE assessments such as the FMA. Furthermore, the clinically meaningful difference using this tool was determined to be 5.7 points [20,21]. The ARAT also includes a subscale that evaluates several musculoskeletal conditions, for which reason it also overlaps with the body function and structure category in the ICF classification [2]. No training for administration is required, but a quick instruction video is available on the official website (http://www.aratest.eu) if needed. Researchers at Soonchunhyang University recently developed standardized instructions in Korean (SCH-ARAT) to ensure accurate assessments. To administer the ARAT, it is necessary to purchase the corresponding equipment.

WMFT

The WMFT consists of 15 functional tasks, including proximal joint movements, hand function, and 2 strength measurements. An advantage of the WMFT is that clinicians are able to assess diverse aspects of UE function, including ROM, strength, manipulation, and coordination [22]. The WMFT can be scored with the time to finish each task and a 6-point functional ability scale from 0 (cannot be performed) to 5 (normal performance). Items are arranged from simple to complex joint movements, in order of difficulty, and each task should be completed within 120 seconds; if a subject fails to complete a task in time, a score of 1 is given [22,23]. Thus, it complements the limitations of the Jebsen-Taylor Hand Function Test (JHFT), which measures only performance time, so that the assessment can be used to understand patients' functional ability and changes therein. Moreover, it has been reported that the WMFT and the MAL are commonly used together in many studies to cover two domains of the ICF [13]. According to Morris and Uswatte [22], the WMFT demonstrates high inter-rater reliability, internal consistency, and test-retest reliability. Additionally, the estimated MCID of the WMFT in the stroke population is 1 point for the dominant hand and 1.2 points for the non-dominant hand [24]. The overall score of the WMFT considering both the mean score of each item and the median score of performance

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time could predict individuals' functional ability. Even though the WMFT requires particular materials for administration, such as checkers, a face towel, and a basket, these are available without the need to purchase test-specific equipment. Furthermore, the standardized set-up template is needed in order to place test objects in an appropriate spot when administering the test. The Korean version of the WMFT has been developed, and it has been confirmed to have only high inter- and intra-rater reliability, but also an excellent correlation with the FMA [25,26].

JHFT

The JHFT consists of seven items that require subjects to execute several functional hand tasks in relation to activities of daily living (ADL) while the required time is recorded for each item. The test can be administered quickly and easily; it takes approximately 15 minutes to complete, and the materials needed for testing are generally accessible [27,28]. The JHFT has normative measurement data for standardized performance; thus, the performance of one subject can be determined using the test. A systematic review reported that the use of the JHFT has been decreasing over time; nevertheless, it is frequently used as an indicator of outcomes in both research and clinical settings, especially for patients with stroke or cerebral palsy [29,30]. Each subscale of the JHFT has demonstrated adequate to excellent test-retest reliability, and the total score of the JHFT showed good to excellent test-restest reliability for both dominant and non-dominant hands (ICCs = 0.84–0.97) [27,31]. Since research has proven that performance ability increases if the JHFT is administered more than four times, it is recommended to consider the practice-effect when interpreting outcome results obtained with the JHFT [32]. In Korea, a standardized scoring system was established for both non-disabled adults and children considering the physical characteristics of Koreans [33,34].

Purdue Pegboard Test (PPT)

The PPT was originally developed as a screening test for manual dexterity in industrial workers performing simple manual labor [35], but it has been broadly used to evaluate hand dexterity in many clinical settings with diverse populations, especially among patients who have cerebral lesions and deficits [36]. It comprises 4 subtests, including placing pins at the holes and assembling each component, and it takes less than 10 minutes to perform, including the instructions. Interestingly, a study discovered that the PPT required more cognitive speed and attention management with hand function in comparison to other UE assessment tools and was useful for anticipating the complex dexterity function needed for daily activities [37]. In Korea, Kang [38] developed a standardized version of the PPT for occupational evaluations of individuals with disability. Since the norms of the PPT in the original article are outdated, however, a study updated the norms for only the assembly task of the PPT with 150 healthy individuals [39].

Nine Hole Peg Test (NHPT)

The NHPT is reported to be the second most frequently used evaluation tool among occupational therapists following the FMA [30]. The NHPT was developed to examine hand dexterity by asking patients to place nine pegs into the holes of a small container as quickly as possible using one hand [40]. It is a cost-effective, simple, and efficient measurement that is applicable to all age groups [41]. The NHPT revealed excellent test-retest reliability for both acute and chronic stroke patients (ICC = 0.85) [42] and adequate correlations with the PPT (r = −0.75 to −0.74) [41]. However, it might not be sensitive enough to find subtle changes because it tracks relatively simple repetitive movements [43].

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Box and Block Test (BBT)

The BBT is commonly used in both clinical and research settings because it is a simple, low-cost, and effective outcome measure to assess manual dexterity. Participants are required to transfer as many small cubes as possible from one box to the other within 60 seconds [44,45]. The score can be calculated by counting the number of blocks successfully transferred by the participants and comparing them with normative data; a higher score indicates better dexterity of the hand. Chen et al. [42] reported that the number of boxes considered as a minimal detectable change (MDC) was 5.5 in the stroke population. The time to administer the BBT is less than 5 minutes, and training to administer the BBT is not mandatory. The test-retest reliability and construct validity of the BBT have been verified in diverse populations, including older adults, children, and patients with stroke [44-47]. Because a previous study found that the score of the BBT was not sensitive to the change of UE function until 5 weeks after onset for stroke patients in the acute phase [48], the BBT is an effective tool to identify patterns of change in the hand dexterity of stroke patients in at least the subacute stage.

MAL

The MAL is a semi-structured interview measure of an individual's functional UE performance in real life to examine the amount of use (AOU) and quality of movement (QOM). The original version of the MAL consists of 30 items, and there are several different versions of the MAL with different numbers of items [49,50]. Each subscale of AOU and QOM is scored using a 6-point system ranging from 0 (never use) to 5 (same use as pre-stroke). A score closer to 5 suggests greater movement quality and increased usage of the affected arm and hand. The MAL requires minimum 10 minutes to administer, and any health professional who has thoroughly reviewed the instructions can administer it [49]. The MDC for the AOU and QOM is estimated as 16.8% and 15.4% of the original scores, respectively. Its correlation with the ARAT is 0.63, and the test-retest reliability of the QOM scale is 0.91 [51,52]. The MAL measurements can be easily conducted because the MAL does not require any equipment other than evaluation sheets and can be administered in both clinical and home settings. Since no specific training is required to administer the MAL, any therapist who reviews the instructions and relevant literature can use this tool.

Functional Independence Measure (FIM)

The FIM is extensively used as a functional-level assessment tool to monitor changes in patients' functional status during the rehabilitation process [53]. A systematic review reported that the FIM is useful in clinical practice because it can predict the post-stroke prognosis quite accurately [54]. The FIM contains 18 items, including self-care, sphincter control, transfer, locomotion, communication, social interaction, and cognition; 13 items are related to motor function impairment and 5 items assess cognitive function. Each item can be rated on a 7-point scale ranging from 1 to 7. A score of 1 means "total assistance" (performs less than 25% of the task), while a score of 7 is defined as "complete independence" [55]. According to Black, Soltis [56], a FIM score of 80 or above at discharge showed high specificity and sensitivity when it came to patients being discharged to their homes. In a quantitative review of studies analyzing the reliability of the FIM, the median inter-rater reliability and test-retest reliability were both 0.95 [57]. Another study indicated that the correlation between motor FIM and the Barthel Index (BI) in post-stroke patients was 0.92 at admission and 0.94 at discharge [58]. The MCID of the FIM in patients with stroke was identified as 22, 17, and 3 for the total FIM, motor subscale, and cognitive subscale, respectively [59]. The FIM is designed to be completed in 30 to 45 minutes, which is very

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time-consuming and laborious. Moreover, this instrument should be administered by trained professionals [58]. At present, there are several restrictions to using the FIM in Korea since it is necessary to pay a fee to the original author and be trained [60].

Modified Barthel Index (MBI)

The MBI is an assessment tool that has been modified from the BI to evaluate the extent to which individuals independently perform ADL. It covers 10 items in the ADL area, including feeding, personal hygiene, bathing, dressing, toilet transfer, bladder and bowel control, chair/bed transfers, stair climbing, and ambulation. Each item has a 5-point scale and the range of the total score is from 0 to 100. It measures what patients actually do, not what they could do; they are allowed to use assistive aids during the test. Higher scores indicate more independence, while lower scores imply less independence in performing ADL [61]. Hsieh et al. [62] suggested that the estimated MCID was 1.85 points in patients with stroke. The Korean version of the MBI has been developed, with excellent inter-rater reliability (with Kendall coefficients ranging from 0.93 to 0.98, $p < 0.01$) and good intra-rater reliability (0.87 to 1.00, $p < 0.01$) [60]. This assessment could be administered via self-report and observation by professionals, and the administration time varies depending on the client's ability [63].

PARTICIPATION

Participation refers to being involved in a life circumstance from the standpoint of society. The term "participation restriction" denotes problems that an individual may experience when participating in life situations [3].

Stroke Impact Scale (SIS)

The SIS is a self-report questionnaire that assesses disability and health-related quality of life after stroke, covering both the activity and participation domains in the ICF framework. It assesses eight domains (strength, hand function, ADL/instrumental ADL [IADL], mobility, communication, emotion, memory and thinking, and participation) on a 5-point scale ranging from 1 to 5, as well as a visual analog scale of 0 to 100 on which patients rate their overall level of recovery from stroke [64]. The latest version, SIS 3.0, is typically administered within 15 to 20 minutes and does not require any professional training. However, a short-form SIS consisting of 16 questions is also frequently used to reduce the administration time and relieve respondents' fatigue [65-67]. The MCIDs for four domains in relation to physical function (strength, hand function, ADL/IADL, and mobility) are 9.2, 5.9, 4.5 and 17.8 points, respectively [68]. Duncan et al. [65] demonstrated that the SIS was more valid, reliable, and sensitive to changes in patients with stroke than other measurements such as the BI and Short Form-36. Since the SIS is a self-reported assessment, it is not appropriate for those in the acute phase or who have cognitive/communication problems. Consequently, the SIS is expected to result in an insightful outcome when administered to patients with minimal to no persistent deficits [69]. The Korean version of the SIS 3.0 has been developed and confirmed to have high reliability and validity [70].

The Assessment of Motor and Process Skills (AMPS)

The AMPS is an observation-based assessment that occupational therapists use to evaluate the quality of ADL task performance in terms of effort, efficiency, safety, and need for assistance in a familiar environment. The assessment includes 2 areas of performance

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skills: motor and process skills. Motor skills are observable goal-directed actions performed by individuals to move or handle their bodies and objects during task performance (e.g., walking, reaching, manipulating, and lifting), while process skills refer to the ability to manage actions in sequential order to complete tasks, such as choosing appropriate tools, gathering ingredients, and organizing spaces. Although the AMPS has not been translated into Korean, it can be utilized in the domestic environment because it was designed to be applicable internationally and cross-culturally (with flexible available options for cultural differences). Only therapists who are trained by the CIOTS (the AMPS provider) can administer the AMPS according to the standardized manual. Special equipment is not needed, and the AMPS can be administered within 30–40 minutes in any setting in relation to the task. As a disadvantage of the AMPS, documentation must be conducted using computer-scoring software in order to obtain valid determinations of the quality of performance and severity compared to normative data [71]. Another limitation is that the AMPS manual and software are not available in Korean.

Canadian Occupation Performance Measure (COPM)

The COPM is a semi-structured, client-centered, and individualized assessment that focuses on clients' own roles and role expectations within a personal context, measuring outcomes in three occupational performance areas: self-care, productivity, and leisure. Clients are asked to prioritize important and challenging aspects of occupational performance and to score their level of satisfaction with current performance, using a 10-point scale ranging from 1 to 10. Problems identified from the COPM can be a basis for the individual's goals and incorporated into the intervention plan [72]. The test-retest reliability of the COPM showed excellent results for both performance (r = 0.89) and satisfaction areas (r = 0.88) in stroke patients, while its validity relative to other assessment tools, such as the Klein-Bell ADL (KB-ADL), FIM, and Satisfaction with Performance Scale Questionnaire (SPSQ) was not significant [73-75]. A change of 2 or more points in both performance and satisfaction areas is clinically significant [76]. Aside from the fact that the COPM is time-consuming (about 20–40 minutes to perform) and difficult to administer, it has the advantage of being applicable to all clients regardless of diagnosis. Moreover, formal COPM training is not required [77]. Currently, an official Korean version of the COPM measure and manual are available for purchase (https://www.thecopm.ca/buy/translations/).

CONCLUSION

In summary, numerous UE assessments with solid validity and reliability are available in the field of rehabilitation. This paper identifies the characteristics of each UE assessment, categorizes each tool within the ICF framework (**Figs. 1** and **2**) and provides information about the availability of a Korean version of the test (**Table 1**). A comprehensive approach to assessments based on the ICF domains is necessary for health care professionals to thoroughly determine individuals' optimal status in an objective manner. Therefore, an understanding of those assessments allows health care professionals to select appropriate assessment tools for people with specific conditions in accordance with a specific purpose.

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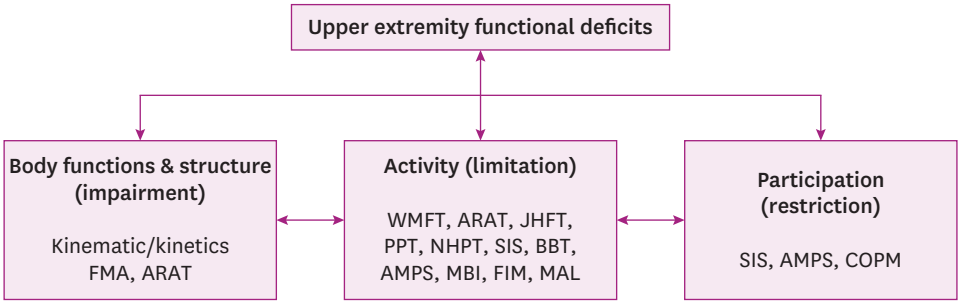

Fig. 1. Upper extremity outcome measures according to the ICF framework.
ICF, International Classification of Functioning, Disability and Health; FMA, Fugl-Meyer Assessment; ARAT, Action Research Arm Test; WMFT, Wolf Motor Function Test; JHFT, Jebsen-Taylor Hand Function Test; PPT, Purdue Pegboard Test; NHPT, Nine Hole Peg Test; SIS, Stroke Impact Scale; BBT, Box and Block Test; AMPS, Assessment of Motor and Process Skills; MBI, Modified Barthel Index; FIM, Functional Independence Measure; MAL, Motor Activity Log; COPM, Canadian Occupational Performance Measure.

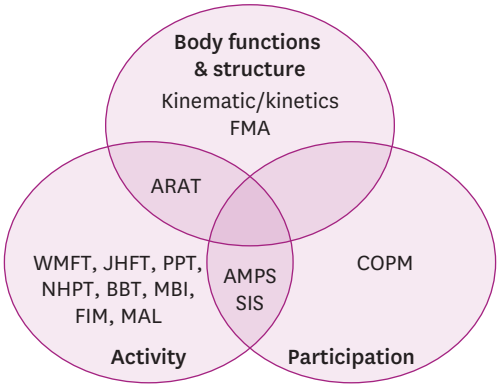

Fig. 2. A diagram of overlapping upper extremity outcome measures within the ICF framework.
ICF, International Classification of Functioning, Disability and Health; FMA, Fugl-Meyer Assessment; ARAT, Action Research Arm Test; WMFT, Wolf Motor Function Test; JHFT, Jebsen-Taylor Hand Function Test; PPT, Purdue Pegboard Test; NHPT, Nine Hole Peg Test; BBT, Box and Block Test; MBI, Modified Barthel Index; FIM, Functional Independence Measure; MAL, Motor Activity Log; AMPS, Assessment of Motor and Process Skills; SIS, Stroke Impact Scale; COPM, Canadian Occupational Performance Measure.

Table 1. An overview of upper extremity functional assessments

UE assessment	ICF domain	Year of development	Time to administer (min)	Required training	Score range	Total score	Normative data	MCID	Equipment purchase	Korean version
FMA (UE)	Body function & Structure	1975	< 30	No	0–2	66	No	4.9–12.4	No	Yes
ARAT	Body function & Structure activity	1981	5–15	No	0–3	57	No	5.7	Yes	Yes
WMFT	Activity	1995	30	No	0–5	75	No	1–1.2	No	Yes
JHFT	Activity	1969	15	No			Yes		Yes	Yes
PPT	Activity	1948	< 10	No			Yes		Yes	
NHPT	Activity	1971	< 10	No			Yes		Yes	
BBT	Activity	1985	< 5	No			Yes	5.5	Yes	
MAL	Activity	1993	> 10	No	0–5	150	No	25.2 (AOU) 23.1 (QOM)	No	No
FIM	Activity	1996	30–45	Yes	1–7	126	No	22 (total) 17 (motor) 3 (cognition)	No	Yes
MBI	Activity	1989	20	No	0–5,10,15	0–100	No	1.85	No	Yes
SIS 3.0	Activity & Participation	2003	15–20	No	1–5	0–100	No	4.5–17.8	No	Yes
AMPS	Activity & Participation	1999	30–40	Yes	1–4		Yes		No	No
COPM	Participation	1991	20–40	No	1–10	20	No	2	No	Yes

UE, upper extremity; ICF, International Classification of Functioning, Disability and Health; MCID, minimal clinically important difference; FMA, Fugl-Meyer Assessment; ARAT, Action Research Arm Test; WMFT, Wolf Motor Function Test; JHFT, Jebsen-Taylor Hand Function Test; PPT, Purdue Pegboard Test; NHPT, Nine Hole Peg Test; BBT, Box and Block Test; MAL, Motor Activity Log; AOU, amount of use; QOM, quality of movement; FIM, Functional Independence Measure; MBI, Modified Barthel Index; SIS 3.0, Stroke Impact Scale 3.0; AMPS, Assessment of Motor and Process Skills; COPM, Canadian Occupational Performance Measure.

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