Fall Risk Reduction in Cognitively Impaired Elderly using Brain-Computer Interface: A Review

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***Abstract*—Decades of research and experimental studies have investigated strategies to reduce older people fall risk. The electrophysiological signal, electroencephalogram (EEG), is a strong basis of brain-computer interface (BCI) for clinical interpretation [1, 2]. EEG correlates with human intention [1]. Objective:The objective of this review is to determine how to use Brain-Computer-Interface reducing the risk of fall on older people.**

Method: A systematic literature(how bout scoping review?) on the following database: EBSCOHost, IEEE, PubMed, CINAHL and MEDLINE; Timeframe starting from 2010 to 2020; The search filter applied for database that enablesBoolean operators, we apply the following keys for reviewing fall risk assessment: (Fall* OR FALLING*) AND (Community Dwelling OR Care home OR Geriatric care OR care unit) AND (Risk OR Risk Assessment OR Fall Risk Factors) AND (Old* OR Elderly OR Older People OR Ageing) AND Nurs* AND Fall Risk Factors.

***Keywords*—** Brain Computer Interface, Cognitive function, fall risk assessment, motor rehabilitation

1. Introduction

Most BCI applications involves assistive technology that help the disabled people with motor movement or communication to improve their well beings[3]

1.1. Risk of fall assessment

Falls in ageing population is a rising public health problem globally. People aged over 65 years are entitled to higher risk of unintentional fall than younger adults and children, leading to fall-related injuries or even as severe as death [4]. Among fall-experienced elderly, those who residing at home, geriatric patients and inpatients adults are the majority [5]. In addition to fall-induced immobility that limits their daily activity, falls pose negative psychosocial effects on elderly such as dependence and social isolation [6]. Falling injuries also requires clinical interventions, bringing high financial burden to their family. To prevent fall of older people, World Health Organization (WHO) suggested effective fall prevention strategies start by exploring variable risk factors and thus develop related healthcare training as well as safer environment to reduce the possibilities for falls [4].

Risk factors for falling varies, hence fall risks assessment tools are widely studied and used for more efficient diagnosis for falls. The accuracy and validity of risk assessment tools should be either tested or supported by evidence before putting in use by patients. As early as 1981, one of the first fall risk assessment tool was established based on incident report data [7]. Later, various assessment tool with quantitative indication of fall risk were developed such as the Morse FALL Scale(MFS)[8], the St. Thomas Risk Assessment Tool in falling elderly inpatients(STRATIFY) [9], Fall Risk Assessment Tool(FRAT) [10].

The environmental settings of the fall event offers clues to specific factors for fall. Hence appropriate selection of risk assessment tool could reveal fall risks and lead to effective fall prevention intervention. In the last decade, many of the emerging fall risk assessment tools were evaluated by retrospective case-control study to identify fall risk factors for older people who are at higher risk of falling. The tools were applied diverse across settings such as in the low-level care facility[11], geriatric care units[12] and acute care hospital [13, 14]. Other novel assessment tools are introduced by multi-factorial statistical approach that incorporate elders' gait performance and cognitive impairment to rate fall risks [15, 16]. An assessment tool may not be suitable for all the settings. For example, the fall risks and factors of older people staying in acute hospital should be assessed differently from those who dwellng in the care community. In fact, evaluation of gait balance is a part of multifactorial fall risk assessment for the residents of community-residing older people [17]. In 2010, the American Geriatrics Society ad British Geriatrics recommend fall risk assessment for the older people above 65 who experienced a fall or had reported difficulties in gait or balance. Popular tests of gait balance includes Timed up and go (TUG) test, the Berg Balance Scale(BBS), Tinetti Performance-Oriented Mobility Assessment(POMA)and One-Legged Stance Test (OLST). For older residents of nursing homes, TUG and POMA are statistically confirmed to be the most useful tools for screening their balance and gait problems[18].

1.2. Correlation between cognitive decline and risk fall (strong or loose)

Poorer gait in older people is associated with falls and limited mobility in daily life. Ageing process causes brain shrinking that damages brain structure resulting in cognitive impairments. Cognitively impaired older people have been shown to have lower capability in gait control, which leads to abnormalities of balance and inability to recover from loss of balance [19] hence falling [20, 21]. Cognitive declines cause neurocognitive disorders in the brain central nervous system with diverse clinical diagnoses such as traumatic brain injury,frontotemporal degeneration and Alzheimer disease, to name a few. The commonly shared characteristics of neurocognitive disorders on older people are declines in execution function (working memory, sensory integration, motor planning),social and cognition, perceptual-motor coordination, and other cognitive factors such as complex attention [22]. Execution functions, complex attention and perceptual-motor function are the three most relevant principal domains of cognitive function to fall risks due to their significant involvement in neural pathways of motor system [23].

Execution function:

Execution function signifies cognitive processes that manipulate information from anterior and posterior brain areas to modulate intent and behaviour. Standing and walking is attention-demanding, high-level, goal-directed controlled task. Execution function impairment may limit individual's ability to walk and stand safely. Clinical and research study in the recent years has establish appreciated evidence of correlation between execution functions and behaviours that produce gait [24]. Elderly require more control of executive processing and memory in gait control [25]. The area of the prefrontal lobe and, in particular, the dorsolateral prefrontal cortex (DLPFC, Brodmann's area 9) and the cingulate cortex (e.g., the anterior cingulate: ACC, Brodmann's areas 24, 32) have been related to the cognitive aspects of EF [24]

Working memory:

Working memory refers to short-term information storage and manipulation of information pieces that are then transfer to achieve high-level cognitive activities such as judging and decision-making. The model of working memory proposed by Baddeley(2000)shows that working memory has several slave components. One of the slave component episodic buffer can temporarily hold integrated chunks from perception and long-term memory. The central executive component in working memory model integrates and coordinates the information chunks to provide planning and decision-making for human. In fact, the neural mechanism of central executive is seen to reflect the neural mechanism of prefrontal cortex. The term executive function actually is thought to be prefrontal functions.

Complex attention:

detail goes here....

Perceptual motor function:

detail goes here....

1.3. Using BCI to reduce cognitive decline:

Motor BCI translates neural signals from the motor areas of the cerebral cortex. Decoding algorithm is developed to interpret the motor-associated cortical activity.(to be justified!!!)

Investigate effective modalities to simulate the organization of brain functional networks and manipulate neural activities by signal processing. Bandpassing neural signals allows to keep a combinations of frequency which give access to certain brain activity components, the action potentials in cortical area. The manipulated activities by BCI could be modulated volitionally which is subject to neuralfeedback training strategy.

1.4. Using BCI to reduce risk of fall

2. Method

3. Search Strategy

4. Study selection

Literature selection criteria should prevent bias and errors as much as possible. In this section, state how you exclude bias.

5. Analysis

6. Quality assessment for the Selected Studies

7. Conclusion

The conclusion goes here.

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