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Reliability and validity of an instrument for the assessment of bradykinesia

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ABSTRACT

Bradykinesia is associated with reduced quality of life and medication non-compliance, and it may be a prodrome for schizophrenia. Therefore, screening/monitoring for subtle bradykinesia is of clinical and scientific importance. This study investigated the validity and reliability of such an instrument. Included were 70 patients with psychotic disorders. Inertial sensors captured mean cycle duration, amplitude and velocity of four movement tasks: walking, elbow flexion/extension, forearm pronation/supination and leg agility. The concurrent validity with the Unified Parkinson's Disease Rating Scale (UPDRS) bradykinesia subscale was determined using regression analysis. Reliability was investigated with the intra-class correlation coefficient. The duration, amplitude and velocities of the four tasks measured by the instrument explained 67% of the variance on the UPDRS bradykinesia subscale. The instrument test-retest reliability was high. The instrument investigated in this study is a valid and reliable alternative to observer-rated scales. It is an ideal tool for monitoring bradykinesia as it requires little training and experience to achieve reliable results.

1. Introduction

Movement disorders frequently occur in psychiatric patients, bradykinesia being one of the most common (Bakker et al., 2013; Shin and Chung, 2012). Bradykinesia is characterized by a reduction in speed and amplitude of movement (DeLong and Wichmann, 2013). It can be an adverse effect of antipsychotic medication or a non-mental symptom of a psychiatric disorder such as depression or psychosis (Whitty et al., 2009), and it has been associated with lower patient self-esteem, reduced quality of life and treatment non-compliance (Fleischhacker et al., 1994; Zaghdoudi et al., 2009). Accurate and reliable assessment of bradykinesia is important for detecting and monitoring antipsychotic-induced side effects. In addition, given that bradykinesia is strongly associated with expression of psychopathology, it should be included in psychiatric diagnosis (Sanders and Gillig, 2012).

Bradykinesia is typically assessed with observer-rated scales, such as the Simpson-Angus Scale (SAS) and the Unified Parkinson's Disease Rating Scale (UPDRS). A limitation of observer-rated scales is that they require extensive training and experience to achieve an adequate inter-rater reliability (Bennett et al., 1997). Furthermore, observer-rated scales also lack the sensitivity and resolution to detect the subtle forms of bradykinesia found in patients with an increased risk of developing psychosis (Koning et al., 2011).

Instrumental methods for assessing bradykinesia have been shown to be more sensitive, reliable and less prone to observer bias than observer-rated scales (Banaszkiewicz et al., 2009; Caligiuri et al., 1998; Caligiuri et al., 2006; Giovannoni et al., 1999; Koning et al., 2011; Salarian et al., 2010). These instruments

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employ mechanical and/or electronic devices to analyze a subject's performance on a motor task. Instruments that assess bradykinesia are typically designed to measure a specific aspect of a motor task as accurately as possible, for example, fluency of handwriting (Caligiuri et al., 2006) or forearm pronation/supination movements (Caligiuri et al., 1998; Koning et al., 2011). Therefore, compared to observer-rater scales, these instruments (Banaszkiewicz et al., 2009; Caligiuri et al., 1998; Caligiuri et al., 2006; Giovannoni et al., 1999; Koning et al., 2011) are liable to over/under estimating severity of bradykinesia, as severity frequently differs per body region. For this reason, we designed an instrument that assesses bradykinesia using a diverse selection of motor tasks.

We hypothesized the novel instrument for assessing bradykinesia investigated in this study is both valid and reliable. This study investigated this instrument's concurrent validity with the UPDRS bradykinesia subscale, and its test–retest reliability in patients with a psychotic disorder.

2. Methods

2.1. Participants

Seventy long-stay inpatients were recruited in a general psychiatric hospital (GGz Centraal Zon & Schild, Amersfoort, the Netherlands). Inclusion criteria were a DSM-IV diagnosis of a psychotic disorder, antipsychotic treatment, good command of the Dutch or English language and full comprehension of the tasks and the goal of the study. Exclusion criteria were injuries or pathologies, other than psychotic disorders, affecting gross motor functioning, or an acute psychotic episode. Each participant provided written informed consent. The study was approved by the Medical Ethical Committee of the Clinical Trial Centre Maastricht.

2.2. Clinical measures

Bradykinesia related demographics, age, gender, height, years admitted, DSM-IV classification, medication affecting bradykinesia, verbal IQ, were acquired from patients' records. Overall severity of psychotic symptoms was assessed with the Clinical Global Impression Schizophrenia scale (CGI-S) (Haro et al., 2003). Scores on this item range from 1, not ill, to 7, among the most extremely ill patients.

The motor examination (Part III) of the Unified Parkinson's Disease Rating Scale (UPDRS) (Martinez-Martin et al., 2013), specifically the validated bradykinesia subscale (Buck et al., 2011), was selected as the golden standard to assess bradykinesia. As the UPDRS bradykinesia subscale assesses bradykinesia more thoroughly than the Simpson Angus Rating Scale or Extrapyramidal Symptom Rating Scale. Although originally designed for Parkinson's Disease (PD), the UPDRS is suitable for assessing drug-induced parkinsonism (DIP), as the phenomenological differences between DIP and PD are minimal (Shin and Chung, 2012). The bradykinesia subscale consists of nine items. On the first eight items subjects were scored twice, for both the left and right body half, on four motor tasks. These motor tasks are finger tapping, hand movements, pronation/supination movements of the hands and leg agility. The ninth item scored the global severity of bradykinesia. Items are scored from 0 to 4 depending on interruptions and/or hesitations, speed and amplitude of movement (Martinez-Martin et al., 2013).

2.3. Instrumental assessment

The instrumental assessment consisted of four motor tasks: (i) walking 20 m at normal pace, (ii) elbow flexion/extension, (iii) forearm pronation/supination, and (iv) seated raising/stomping of foot (Mentzel et al., in press). Subjects were instructed to perform tasks ii, iii and iv for 25 s, with their dominant arm or leg. The key instructions given to subjects for tasks ii, iii and iv were to focus on performing the tasks as fast as possible and to try and perform large movements. After approximately 15 s they were motivated to keep up the tempo and maintain the large movements. For the walking task the key instructions were to walk at their own normal pace and to turn around and walk back after passing the marker on the floor. In case of interruptions during the tasks they were reminded to keep on going. The instrument measured the dominant limbs' performances on these tasks, as the expression of DIP is generally bilateral and symmetric (Shin and Chung, 2012). The instrument measured the same aspects of the motor tasks as the UPDRS, thus ensuring its content validity approaches that of the UPDRS. Subjects' overall speed and amplitude of movement on the tasks were assessed as their average cycle/stride duration, amplitude and velocity. Regularity of the rhythm on the tasks was assessed as the variance of the tasks cycle/stride duration/amplitude and velocity.

The instrumental setup is illustrated in Fig. 1. Performances on the four motor tasks were registered using five wireless inertial sensors (MTw, XSENS, Enschede, the Netherlands). In contrast to the inertial sensors used in previous studies (Patel et al., 2009; Salarian et al., 2010), this study used inertial sensors that feature an adaptive Kalman filter. This filter greatly improves the accuracy with which amplitude and velocity of movement are registered (Wei and Wang, 2001). Therefore, these sensors are well suited for the assessment of a wide range of tasks. Sensors were attached to the subjects' dominant upper and lower arm and leg, and waist using Velcro straps (Fig. 1). Sensor data was received and processed using software developed in Matlab 2011b (The MathWorks Inc., Natick, MA, USA). Sensor output, its absolute orientation over time, was coupled to a virtual 3D model of the subject (Fig. 1), adjusted for body height (Herman, 2007). This virtual representation of the subjects were used to determine their performances on the four tasks, i.e. their average and SD cycle/stride duration, amplitude and velocity.

Cycle duration, amplitude and velocity of the elbow flexion/extension, forearm pronation/supination and foot raising/stomping tasks were determined using the joint angles of the subjects' 3D models. Joint angles were calculated using the dot product between the vectors of the limbs adjacent to the respective joint, with the exception of the foot raising/stomping task in which the dot product was calculated between vector of the upper leg and its projection in the transversal plane (i.e. parallel to the floor). Then, this data was filtered using a low pass bidirectional Butterworth filter. To achieve the most accurate results, cut-off frequencies were determined by adding two Hertz to the highest power frequency found with Direct Fourier Transformation. Finally, the duration, amplitude and velocity of each cycle was determined with a peak detection algorithm, by determining subsequent minima and maxima in the angle of the joint over time (Fig. 1).

To assess the duration, amplitude and velocity of a stride on the walking task, the position of the ankle in the transversal plane, the plane parallel to the ground, over time was determined with the data from the 3D models. The gait task required regular walking to be differentiated from turning. Therefore, periods of turning were defined as periods in which the sensor attached to the waist rotated over 160 degrees. Subsequently, distances in the transversal plane between the ankle's position over time and its average position were determined. The resulting data was filtered and analyzed using the same methods used for the other tasks. After which the durations, amplitudes and velocities of the strides were determined.