Postural Sway and Clinical Characteristics in Patients with Psychotic Disorders: A Review

Abstract

Postural instability is a feature that is frequently observed in patients with psychotic disorders. Previous studies applied rating scales or behavioral test to assess postural instabilities. Recently, a pressure-sensitive platform has been used to study detailed characteristics of postural sway and regulation. However, characteristics of posturography indices in patients with psychotic disorders have not been well documented. To integrate the findings from studies that assessed postural sway using posturography in patients with psychotic disorders, we conducted a systematic review. Following database literature search, we identified nine eligible articles. Assessment conditions and indices of postural stability varied between studies. Postural control was associated with negative and general psychopathology in two studies. Two studies reported associations between posturographic variables and medication dose, whereas four studies reported no associations. This review identified the need to develop standards to assess postural sway in patients with psychiatric disorders. Further studies need to report associations between postural sway and confounding factors.

Keywords: postural balance; schizophrenia; bipolar disorder; psychosis; psychiatric symptom; antipsychotics

Introduction

Mental disorders, particularly psychotic disorders, strongly affect daily lives and functioning of individuals [1-3]. Psychotic disorders present with positive symptoms, (e.g., paranoia and hallucination), negative symptoms (affective flattening and withdrawal), and cognitive disturbances [4-6]. In addition to these core psychiatric symptoms, neurological soft signs (e.g., motor coordination and sensory integration) have been observed in a subgroup of patients [7-14]. Recently, postural instabilities in patients with mental disorders have been reported. Marvel et al. demonstrated greater postural sway in patients with schizophrenia and schizoaffective disorders [15], which was one of the initial studies focusing on postural instability in mental disorders using posturography. Chronic alcohol use disorders are also reported to be related with greater postural sway and gait problems [16].

A number of brain imaging studies revealed decreased cortical volume, structural abnormalities, and dysfunction of neural circuits in patients with psychotic disorders. As noted in previous studies, associations between neurological signs and abnormalities in cerebellum were reported in psychosis [17-20]. The cerebellum integrates visual, proprioceptive, and vestibular signals, and controls the body’s balance. Postural control is regulated by various neural structures, such as brain stem, spinal cord, and cerebellum and based on sensory signals. Previous studies reported abnormalities in cerebellum of patients with schizophrenia [21]. Additionally, cerebellar dysfunction could account for some of the psychiatric and neurological symptoms and cognitive impairment in patients with schizophrenia [22]. Cerebellar dysfunction was also reported in neuroleptic naïve patients [23].

Standing posture is regulated by various postural control systems, including musculoskeletal, neuromuscular, and sensory systems [24]. Clinical balance assessment includes functional, systems, and quantitative assessments [24, 25]. Functional assessment is used in examining the effectiveness of interventions. Systems assessment evaluates posture and balance deficits and is helpful to develop an effective intervention plan. Recently, quantitative assessment has been used in research settings [25, 26]. Posturography has been used to assess deficits in standing posture and balance control by evaluating subtle changes, therapeutic efficiency, and risk of falls [27-29]. Postural regulation is a complex behavior that depends on central and peripheral nerves and musculoskeletal systems. Owing to the wide variety of influential factors, it is difficult to determine the cause of postural instabilities in patients with physical disorders [9, 30-32].

Posturography assesses postural stability and characteristics of regulation of balance control in a standing posture based on locus length (sway path) and velocity of center of foot pressure and area of sway in an individual. The factors influencing postural instability in psychiatric populations, such as medication dose, have not been clearly identified. Additionally, the association between postural sway and other clinical variables is controversial. A study documented that schizophrenia patients with comorbid alcoholism showed a compounded deficit of ataxia of gait [33]. The aim of this review was to integrate the findings from studies that assessed postural sway using a pressure-sensitive platform in patients with psychotic disorders.

Methods

Search strategy

A systematic literature search was conducted on the Medline OVID and PsycINFO databases, containing articles that assessed postural stabilities in patients with psychotic disorders. The following keywords were used in the database search: “schizophrenia,” “schizoaffective disorder,” “bipolar disorder,” “psychosis,” or “psychotic disorder” and “body sway,” “postural stability,” “postural instability,” “postural control,” “postural sway,” or “posturography.” Reference lists of retrieved articles were also reviewed manually for additional relevant publications not identified in the initial electronic search.

Study selection

Eligibility for the review consisted of studies that assessed postural sway using posturography in patients with psychotic disorders (i.e., schizophrenia, schizoaffective disorder, psychotic disorder, and bipolar disorder). We further included studies of individuals at ultra-high risk of psychosis. We excluded studies that did not present quantitative results of patients. The reviewer (H. F.) screened articles for eligibility.

Results

Results of literature search

Of the 768 articles obtained from the literature search, ten articles [15, 34-42] met the selection criteria. However, some participants overlapped between the studies of Bernard et al. (2014) and Dean et al. (2015) [35, 37]. Therefore, we excluded the study by Dean et al. (2015) from the subsequent review.

The study selection process is shown in Fig. 1. Most of the selected articles were observational studies. One study was a controlled trial that applied postural sway as an outcome measure of the intervention [38]. A summary of the included studies is presented in Table 1.

Results of index of postural stability and conditions of assessment

The conditions of assessment varied between studies. Eye condition (open and closed) and feet position (open base and closed base) were mainly used as independent factors. Most studies employed sway area as index of postural instability (n = 6), followed by average locus length (n = 3), fluctuation (n = 2), frequency (n = 2), and velocity (n = 1) of sway. The duration of data acquisition varied from 10 to 180 seconds.

Associations between postural sway and clinical variables

Two studies reported significant associations between psychiatric symptoms and postural sway [35, 39]. Other studies did not conduct correlational analyses. Six studies examined the effects of medication, with two studies reporting an association between posturographic variables and medication dose [40, 41]. One of these two studies, which had the largest sample size, reported that the use of quetiapine increased postural sway [40]. The remaining four studies reported no significant relationships with medication dose. Only one study conducted correlational analysis to examine relationships between extrapyramidal symptoms and postural sway, and confirmed that they were not significantly associated [15]. In two studies, patients with extrapyramidal symptoms were excluded from the analysis [36, 39]. History of alcohol abuse or dependence was examined in three studies as confounding factor; however, no substantial effect of history of alcoholism was reported. Three studies reported that history of alcohol abuse or dependence did not affect their findings.

Discussion

This review study aimed to examine the characteristics of postural instability in patients with psychotic disorders. We reviewed nine quantitative studies of posturography in patients with psychotic spectrum disorders.

Conditions of measurement

In the review, the assessment conditions of postural sway varied between studies. Most studies consisted of conditions that combined eye condition (open and closed) and foot position (open and closed base). Visual information is one of the major factors affecting postural regulation. Loss of visual input results in greater postural sway. Early visual information processing is reported to be affected in patients with psychotic disorders [43, 44]. Patients with psychotic disorders swayed more during closed-eye conditions, similar to normal individuals [15]. While visual input is a major component affecting postural regulation in patients with schizophrenia, it has not been examined whether the magnitude of this effect differs from that in healthy individuals.

Area of sway was the most frequently used index in the included studies. This index refers to the area covered by displacements of the center of foot pressure and decreases with better stability. A few studies employed locus length, fluctuation, frequency, and velocity of sway. All indices of postural stability are moderately correlated and represent slightly different components of postural sway [45]. Thus, the results, including correlations between indices and clinical variables, may differ between studies. Fluctuation and frequency analyses may represent useful approaches to assess the complex characteristics of postural sway in patients with psychosis [39]. Low and high frequency components were associated with vestibular system (low frequency components) and proprioceptive inputs (high frequency components) [46].

These approaches could identify the involvement of each systems in patients with psychiatric disorders.

The duration of data acquisition also varied between studies. Because indices of postural sway are not valid or reliable when the duration of assessment is less than 10 s, we needed to set an adequate duration to obtain valid and reliable results of postural sway [47]. This may also be an important factor when attempting to replicate findings from other studies. Moreover, performance of postural control during 30 s and 180 s might reflect different components of the postural regulation process. Thus, standards for the assessment of postural stability in psychiatric patients are needed to provide equality of the assessment and to accumulate various research findings. Heterogeneity of conditions for the assessment of postural sway might prevent integration of research findings.

Relationships between clinical variables and postural stabilities

Postural instabilities were associated with negative and general psychiatric symptoms. This finding is consistent with previous studies that examined associations between neurological soft signs and psychiatric symptoms [48, 49]. Prior studies consistently showed that negative symptoms are related to performance parameters reflecting various brain functions (e.g., cognitive function, general level of intelligence, and executive functions) [50-52]. Postural instability and psychiatric symptoms seem to be associated; however, most studies did not specifically examine these associations, which should be confirmed in larger studies.

The relationship between antipsychotic medication and postural instability was controversial in the included studies. Two studies reported relationships between postural sway and medication dose [40, 41]. One of these studies by Koreki et al. examined differences between types of antipsychotic drug, suggesting that the pharmacological function of each drug could influence the balancing function [40]. Chlorpromazine and risperidone equivalent is often used in studies to evaluate influences of medication [53], which does not reflect differences in pharmacological functions of the drugs. Therefore, further studies should identify the particular types of medication that could result in greater postural sway. Such an effect could also be an important consideration when evaluating side effects of antipsychotic medications.

Most studies did not examine the relationships between side effects and postural stabilities (e.g., patients with extrapyramidal symptoms were excluded from the analysis). Thus, we could not draw any definitive conclusions as to the influence of extrapyramidal symptoms on posturographic variables. Extrapyramidal symptoms could be affected by medication and history of alcohol dependence/abuse, as shown in previous studies [33, 54, 55]. History of alcohol dependence/abuse could affect postural regulation; however, several studies reported that history of alcohol dependence/abuse did not have substantial effect on postural stability [15, 36, 39].

Abnormalities of the cerebellum in psychotic disorders have been reported by a large number of studies [56-59]; however, the links with postural sway have not been investigated. Bernard et al. (2014) suggested that cerebellar networks are involved in postural regulations in individuals at ultra-high risk for psychosis [60]. They employed functional connectivity magnetic resonance imaging to examine connectivity of the cerebellar networks. Poorer connectivity was associated with greater postural sway. Further study is needed to investigate cerebellar involvement in postural regulation in patients with psychotic disorders.

Implications and limitations

Several studies suggested that therapeutic approaches to develop internal experience, monitoring function, and body awareness might be useful for reduction of psychiatric symptoms [61-64]. Discrepancy between subjective and objective evaluation may be a potential factor that affects monitoring of sensory information [65]. Therefore, postural stability could be a potential objective indicator of treatment outcome. Longitudinal studies are needed to confirm the significance of posturographic variables in this context.

In this systematic review, we only included nine studies. Additionally, the number of patients in individual studies was small. An insufficient number of participants leads to lack of statistical power, which results in fewer significant associations. This concern also limits the generalizability of the current findings. Further studies are needed with larger samples including patients during particular illness phases (e.g., first episode and chronic patients). Only one study employed a longitudinal observational approach [37]. To examine the effect of illness progression and medication use, longitudinal studies are essential to understand the characteristics of postural abnormality in patients with psychosis.

Conclusions

We reviewed studies investigating postural sway in patients with psychotic disorders. Assessment conditions and indices of postural stabilities varied between studies. Postural control was associated with negative and general psychopathology. Relationships between medication and postural instability were not clearly established. This review identified the need to develop standards to assess postural sway in patients with psychiatric disorders.

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Figure legends

Fig. 1

Flow diagram the search process for selection of studies

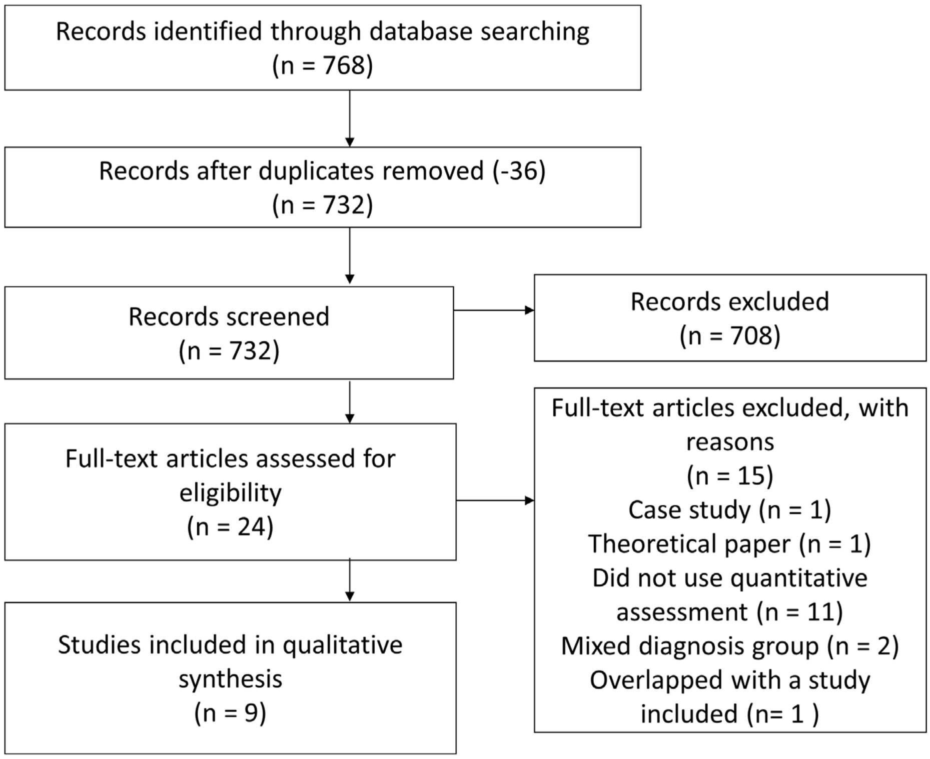

Table 1 List of studies examining postural stability using pressure-sensitive platform in patients with psychotic disorders

Author (year)	N	Diagnosis (number of patients)	Conditions of assessment	Mean age (SD) [years]	Duration [s]	Indices	Relationships with posturographic variables			
							Psychiatric symptoms	Medication	EPS	Alcohol use
Marvel et al. (2004)	36	schizophrenia (23), schizoaffective disorder (13)	10 conditions (8 conditions: feet [together or shoulder width] x arms [at side or out in front] x eyes [open or closed]; 2 conditions: tandem feet, arms at side [eyes open or closed])	45.0 (7.3)	10	length	NA	no relationship (CPZ)	no correlation with AIMS	no relationships
Ahlgren-Rimpilainen et al. (2010)	22	schizophrenia (22)	2 conditions (eyes open and closed)	NA	30	velocity, length	NA	NA	NA	NA
Bolbecker et al. (2011)	16	bipolar disorder (16)	4 conditions (eyes [open or closed] x feet [open or closed base])	38.6 (10.5)	120	sway area, fluctuation	NA	no relationship (CPZ)	no EPS patients	no relationships
Koreki et al. (2011)	402	schizophrenia (388), schizoaffective disorder (5), delusional disorder (3), psychotic disorder not otherwise specified (3), acute and transient psychotic disorder (3)	1 condition (with eyes closed and feet together)	55.5 (14.3)	30	sway area	NA	associated with CPZ and use of quetiapine	NA	NA
Kent et al. (2012)	27	schizophrenia (14), schizoaffective disorder (13)	4 conditions (eyes [open or closed] x feet [open or closed base])	41.9 (9.1)	120	sway area, fluctuation	correlated with general psychopathology	no relationship (CPZ)	no EPS patients	no relationships

Ikai et al. (2013)	49	schizophrenia (44), schizoaffective disorder (4), psychotic disorder not otherwise specified (1)	1 condition (eyes closed and feet together)	53.1 (12.3)	30	sway area, length	NA	NA	NA	NA
Stensdotter et al. (2013a)	11	schizophrenia (7), delusional disorder (2), acute psychosis (1), unspecified psychotic disorder (1)	3 conditions (eyes open, eyes closed, and eyes open and standing on yielding surface)	26.8 (5.4)	180	frequency	NA	associated with risperidone equivalents	NA	NA
Stensdotter et al. (2013b)	12	schizophrenia (7), delusional disorder (2), acute psychosis (1), unspecified psychotic disorder (1), dissociative disorder (1)	2 conditions (baseline or cognitive tasks; eyes open, and feet together)	24.1 (2.2)	60	sway area, frequency	NA	no relationship (risperidone equivalents)	NA	NA
Bernard et al. (2014)	34	Ultra-high risk for psychosis (34)	4 conditions (eyes [open or closed] x feet [open or closed base])	18.6 (1.9)	120	sway area	correlated with negative symptoms	NA	NA	NA

AIMS abnormal involuntary movement scale, *CPZ* chlorpromazine equivalent, *EPS* extrapyramidal symptoms, *NA* not available