Schizophrenia Bulletin vol. 47 no. 4 pp. 877–879, 2021
doi:10.1093/schbul/sbab057
Advance Access publication 5 May 2021

EDITORIAL

New Insights Into Sedentary Behavior Highlight the Need to Revisit the Way We See Motor Symptoms in Psychosis

Vijay A. Mittal*[,1], Jessica A. Bernard[2], Gregory P. Strauss[3], and Sebastian Walther[4]

[1]Department of Psychology, Northwestern University, Evanston, IL; [2]Department of Psychological and Brain Sciences, Texas A&M University, College Station, TX; [3]Department of Psychology, University of Georgia, Athens, GA; [4]University Hospital of Psychiatry, Translational Research Center, University of Bern, Bern, Switzerland

*To whom correspondence should be addressed; Department of Psychology, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208, US; tel: 847-467-3380, fax: 847-491-7859, e-mail: vijay.mittal@northwestern.edu

Sedentary behaviors encompass a range of light intensity physical activities, such as screen time or sitting when socializing, commuting, or doing desk-based work.[1] In general, the time spent engaging in sedentary behaviors is linked to mortality, supporting the notion that "sitting is the new smoking." Individuals with schizophrenia represent a population characterized by high levels of this problematic behavior, and our field has historically attributed it to several external sources. First, it has been tied to the soporific effects of early pharmacological treatments. More recently, the contribution of drug-induced akinesia is less of an issue with atypicals, but these can induce a metabolic syndrome that is also associated with sedentary behaviors. Another source of sedentary behavior could be under-stimulating environments, which is why occupational therapy was the most effective treatment for psychosis in the 19th-century asylums. Much more recently, in a study of schizophrenia patients within a supported work program, we found low activity to correlate with apathy scores only on weekends, when patients were on their own, but not during weekdays in the program.[2] Of course, sedentary behavior and reduced motor output more broadly are also core features of negative symptoms. For example, reduced goal-directed and physical activity is a core feature of avolition, reduced body gestures and facial displays of emotion are part of blunted affect, and reduced speech output is core to alogia.[3,4] Indeed, a recent symptom network study demonstrated a critical link between motor deficits and negative symptoms, particularly blunted affect and alogia.[5]

However, sedentary behavior is deceptively complex, and our understanding continues to evolve. For example, aberrant motor behavior constitutes a core symptom dimension in psychosis[6] and among these motor signs, there are strong conceptual reasons to believe that hypokinetic forms in particular (eg, catatonia, rigor, or psychomotor slowing) may also dramatically hamper physical activity and render patients to prefer sedentary behaviors. Pieters and colleagues,[7] added an important new element to this idea, providing strong empirical evidence that both sedentary behavior and hypokinetic motor symptoms in patients with schizophrenia were tightly coupled. This paper indicates that motor dysfunction should be added to the list of contributing factors. But it is also noteworthy to consider that while there was a significant relationship with motor signs, much of the variance for sedentary behavior remained unexplained (~80%). It is noteworthy that medication dosage, a historically important potential secondary influence, contributed to less than 10%. Given this unexplained variance, and that the investigation was not designed to establish causality, the reported association also raises the question of whether sedentary behavior should be considered a primary motor symptom in its own right? This is an exciting question, but examining the issue leads us directly into some fundamental problems with the way motor symptoms are currently conceived in our field. For if sedentary behavior, at least in part, represents a primary physical or motor symptom, then there is no clear "good" place in the current organizational scheme to consider it as such.

This speaks to a broader issue with the current nosology of motor symptoms in psychosis. Because of waxing and waning emphasis on motor symptoms since the time of Kraepelin and Bleuler until the present, confusion about independence from neuroleptics, and poor communication between the fields of neurology and psychiatry, our current system of categorizing motor behaviors across the psychosis spectrum is at best understood as convoluted to niche experts and simply off-putting and perplexing to everyone else. For example, signs of motor dysfunction can be viewed as either *positive* (ie, "spontaneous," tied-to pathophysiology and not driven

by medication, hyper-dopaminergic movements such as dyskinesia), *negative* (spontaneous hypo-dopaminergic movements including, psychomotor slowing, rigidity, and tremor), or falling into a larger *other* miscellaneous category (including both cerebellar-thalamic, cortico-cortical, and/or brain stem-cortical circuit abnormality based motor symptoms involving clumsiness, sensory-motor integration deficits, compromised postural control, deficits in motor learning and timing, deficits in saccadic eye movement, and dysfunction in the execution, perception, and interpretation of gestures). At present, this unsatisfying later category is where a primary sedentary motor symptom might fit. Furthermore, motor dysfunction symptoms can also be categorized as *secondary* (ie, these motor symptoms may share a common phenotype with several of those noted earlier in the list, but are distinguished in that they are secondary to things like enrichment and medication and negative symptoms) and *unknown/unclassified* (including a broad area of broad bodily/proprioceptive symptoms, as well as soft sign categories relating to motor sequencing). Critically, while there are some excellent contributions that organize and/or discuss the mechanisms behind just a few behaviors (eg, ref.[8–13]), there are no common organizational principles or guiding theories linking all of these varied phenomenology under a single umbrella system or model.

Fortunately, our expanded understanding of these phenomena, and insights from novel frameworks for conceptualizing psychiatric disorders (eg, RDoC, HiTOP, SyNoPsis), have provided some useful clues for how we might go about organization. Indeed, the RDoC framework has already led to new investigations of motor signs and symptoms in major depressive disorder,[14,15] with similar potential in psychosis.[16] Relatedly, from a circuitry-centric perspective, distinct deficits in performance domains can be dissociated both within and across motor circuits at the cortical and subcortical levels, and this may serve as a useful framework for creating a taxonomy of motor symptoms in psychosis.[7] However, while several groups have started this particular effort (the authors organized *positive, negative*, and *other* categories in this way in the prior section), the work is far from complete, and at this point, one can only speculate as to the circuitry associated with sedentary behavior. One possibility is that sedentary behavior could result from the mere inability to plan and execute movements (anterior cingulate cortex-pre supplementary motor area-striatum-subthalamic nucleus on a circuit level).

However, this is only one option for a unifying categorization. The predictive value of motor behaviors in psychosis spectrum disorders is also a possible organizing framework, as motor dysfunction has been shown to predict conversion to psychotic disorders in at-risk populations,[17] while recent advances have demonstrated that neurological soft signs at first episode are associated with a non-remitting course of illness a decade later.[18] Careful longitudinal investigation including sedentary behavior may help in the formation of a comprehensive motor symptom taxonomy. We might also come to define aberrant motor behaviors within a broader physical symptom category of body and self-disturbance. For example, Lee and colleagues[19] utilized an innovative virtual reality paradigm to examine disturbance in the self-other boundary in schizophrenia and observed an increased uncertainty in social situations specifically. As with sedentary behavior, this is an important finding highlighting a symptom, loosely tied to physical/movement domain, that does not currently enjoy a clear conceptual link to the broader range of related symptoms in psychosis. Further, a construct looking at motor vs psychomotor symptomatology[9] may allow us to effectively incorporate a range of the more established positive and negative symptoms as well as the *unknown/unclassified* and *other* symptoms such as sedentary behavior. Another more distal option might include organization based on related functional deficits. For example, utilizing an innovative eye-tracking paradigm, Gupta et al.[20] observed deficits in the the perception of abstract gestures in those at clinical high-risk for psychosis. As gestures play a critical role in social interaction, deficits in interpreting particular forms of this motor behavior might contribute to broader social disability. Medication approaches may also be a useful organizing principal.

In order for this important area to evolve and mature, we must generate, debate, and refine organizational and related conceptual models. With respect to the later, it will be essential for these to include clear falsifiable predictions, along with suggested lines of studies needed to prove or disprove core tenants. As highlighted in the case of sedentary behavior, theoretical conceptions will need to consider primary and secondary influences. Accompanying studies should incorporate experimental, neuromodulatory and pharmacological challenge methods to get at directionality. Here, new animal models would also have enormous potential. In order to avoid contributing further to a convoluted nosology instead of remedying the issue, new organizational schemes and conceptual models will need to carefully be presented in reference to one another, and either challenge or incorporate one another as well. Ideal models would fit within the context of broader theories of psychosis, or mental illness and an eye toward identification, prediction, subtyping, and treatment is essential. Indeed, researchers in this area are increasingly recognizing the potential for motor signs to play a central role in treatment development and outcome research.[21] Ongoing discourse via published works along with dedicated workgroups may help to facilitate this process as well.

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