APPROVAL SHEET

Title of Thesis: Tracking Physical Activity Along the Psychosis Spectrum

Name of Candidate: Nicole Dorothee Andorko

Master of the Arts, 2017

Thesis and Abstract Approved: 

Jason Schiffman, Ph.D., Professor,

Department of Psychology,

Human Services Psychology Program

Date Approved: 11/3/17

NOTE: *The Approval Sheet with the original signature must accompany the thesis or dissertation. No terminal punctuation is to be used.

ABSTRACT

Title: **TRACKING PHYSICAL ACTIVITY ALONG THE PSYCHOSIS SPECTRUM**

Nicole D. Andorko

Directed By: **Jason Schiffman, Ph.D., Professor, Department of Psychology, Human Services Psychology Program**

Conceptualization of psychosis on a symptom severity continuum has recently been supported by findings of high rates of people presenting with sub-threshold, non-clinical psychosis symptoms (PLEs). Sedentary behavior is common in people with psychotic disorders, and is associated with poor physical and mental health. Recent studies have examined levels of physical activity in individuals at high risk for psychosis, but none have studied a non-clinical sample displaying PLEs. The present study investigates the relation between PLEs and physical activity within an undergraduate student population (n = 45), using Ecological Momentary Assessment (EMA) methods in which questionnaires were sent to mobile phones, minimizing recall-bias, and improving ecological validity. Questionnaires were sent six times a day, for one week, and assessed activity (quantified as sedentary, light, moderate, or vigorous) since last questionnaire. A total activity score was calculated using weighted sublevel activity scores. Self-reports assessing PLE were also conducted. Five separate multiple regressions were run in which PLEs were regressed onto level of activity (total, vigorous, moderate, light, and sedentary) while controlling for sex, age, body-mass index (BMI), and drug use. Results indicate PLEs predicted total physical activity, but models predicting sub-levels of activity were not significant. Findings extend prior literature on activity in individuals across the psychosis spectrum to suggest those within the less severe, subclinical PLEs population are also less physically active.

TRACKING PHYSICAL ACTIVITY ALONG THE PSYCHOSIS SPECTRUM

By

Nicole D. Andorko

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, Baltimore County, in partial fulfillment
of the requirements for the degree of
Masters of Arts
2017

Acknowledgements

This work was supported in part by funding from the Maryland Department of Health and Mental Hygiene, Behavioral Health Administration through the Center for Excellence on Early Intervention for Serious Mental Illness (OPASS# 14-13717G/M00B4400241).

Thank you to all of my family for your ongoing encouragement and support. Special thanks to my husband, Jim, for being beside me through it all (and also for proof-reading my final document).

Thank you to my mentor, Jason Schiffman, who has provided invaluable input throughout this entire process. Through your guidance, I have learned what it means to be a researcher with goals to improve the lives of others.

Thank you to the rest of my committee, Shuyan Sun and Bronwyn Hunter, for your creative ideas and amazing brainpower. You all have guided me through this project and offered endless encouragement.

Finally, extra special thanks to my amazingly supportive, creative, and spirited labmates and cohort. You all make this a fun ride.

Table of Contents

List of Tables

List of Figures

Tracking Physical Activity Along the Psychosis Spectrum

The Benefits of Physical Activity

Physical Activity (PA) is an important factor in overall wellbeing. Increases in PA, even if modest, have a large impact on improving overall health and quality of life (Janssen & LeBlanc, 2010; Kohl et al., 2012; Reiner, Niermann, Jekauc, & Woll, 2013). A lack of PA, or a high level of sedentary behavior, is associated with increases in morbidity due in part to the strong association between sedentary behavior and metabolic disease (Haapanen, Miilunpalo, Vuori, Oja, & Pasanen, 1997; Knowler et al., 2002; Williams, 2001). The effect of sedentary behavior is so great that PA treatments have been used more effectively to control and prevent certain disease progression (e.g., type 2 diabetes) relative to medication treatments (Knowler et al., 2002; Richardson et al., 2005). A systematic meta-analysis of longitudinal studies showed PA to be associated with a 28-37% marked decrease in all-cause mortality, even after adjusting for other relevant risk factors (Nocon et al., 2008).

The positive effects of PA on mental health are equally pronounced. Numerous population and experimental studies support an association between increases in PA and improvement in multiple areas of psychopathology (Stathopoulou, Powers, Berry, Smits, & Otto, 2006) and self-perception of mental health (Herman, Hopman, & Sabiston, 2015). Higher levels of PA are linked with a decreased prevalence in symptoms for mood (Craft & Landers, 1998; Ten Have, de Graaf, & Monshouwer, 2011), anxiety (including panic disorder, agoraphobia, social phobia, and specific phobia; Goodwin, 2003), substance-use (Bardo & Compton, 2015; Ten Have et al., 2011), and eating disorders (Goñi & Rodríguez, 2007), as well as with improvements in quality of life (Schmitz, Kruse, & Kugler, 2004) and mental well-being (Ho, Louie, Chow, Wong, & Ip, 2015). Prospective examinations note increased PA decreased

prevalence of anxiety, somatoform, and dysthymic disorder in young adults (Stroehle, et al., 2007) and depressive and anxiety disorders in older adults (Pasco et al., 2011). Further, interventions manipulating physical activity in young adults have linked increases in physical activity to clinically meaningful improvement in depression symptoms (Parker et al., 2016; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014) and quality of life (Rosenbaum et al., 2014).

Animal and human studies further show that increases in PA lead to improvements in neurocognition across the lifespan. Specifically, numerous cross sectional (Boots et al., 2015; Hillman, Kramer, Belopolsky, & Smith, 2006; Kamijo & Takeda, 2009) and experimental (Cahill et al., 2015; Pang & Hannan, 2013; Strassnig et al., 2015) studies have demonstrated positive associations between increased PA and memory, processing speed, cognitive flexibility, and executive functioning. Further, longitudinal investigations (Smith et al., 2014; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001) suggest higher levels of PA may in fact promote neurogenisis and effectively attenuate age-related demeyelination, thus leading to improvements in overall cognitive abilities in older adults as well as in other individuals with progressive neurocognitive decline. In children and young adults specifically, PA (physical fitness as well as single sessions of activity) led to improvements in cognitive functioning and learning (Bustamante, Williams, & Davis, 2016; Donnelly et al., 2016). Neurocognitive improvements are an especially important factor in populations with severe mental illness, as cognitive deficits frequently exacerbate already impairing psychopathological symptomatology.

Research on the specific mechanisms through which these changes are occurring is still preliminary. Possible drivers include (a) biochemical changes, such as increases in serotonin and brain-derived neurotrophic factor (BDNF) which then lead to improvements in affect (the so

called “endorphin effect”; Stathopoulou et al., 2006) and increased neuroprotection (Seifert et al., 2010; Zschucke, Gaudlitz, & Stroehle, 2013); increased hippocampal cell proliferation (Bjørnebekk, Mathé, & Brené, 2010); and decreases in cortisol secretion, a known stress-related hormone (Nabkasorn et al., 2006); (b) physiological changes such as improved circulation and vasculature (Convertino, Bloomfield, & Greenleaf, 1997); (c) psychological changes such as enhanced self-confidence, and improved perception of competency (Faulkner & Carless, 2006; Liu, Wu, & Ming, 2015); and (d) social changes, such as improvements in social support (Van Dyck, Teychenne, McNaughton, Bourdeaudhuij, & Salmon, 2015; VanKim & Nelson, 2013). Most likely, a combination of factors is contributing to the improvements, leaving future research to explore the interrelations of these potential mechanisms.

Psychotic Disorders and Schizophrenia

Psychotic disorder is a broad term used to describe a category of psychopathological disorders characterized by the prominent presence of psychotic symptoms. Although the term psychotic has received multiple definitions historically, current research generally understands psychotic symptoms as those that signify a break from reality. More specifically, psychotic symptoms are currently defined as delusions, hallucinations, disorganized speech and communication, and negative symptoms. Typically, these symptoms occur without an individual’s insight into the disconnect from reality (APA, 2013). Multiple disorders are classified by *The Diagnostic and Statistical Manual of Mental Disorders, Fifth edition* (DSM-5) as psychotic, yet schizophrenia is often considered the prototypical disorder and is the most common and impairing within the classification.

Schizophrenia is a distressing and often disabling disorder characterized by numerous interpersonal and social deficits as a result of cognitive, behavioral, and emotional dysfunctions

(APA, 2013). Impairments are due to a range of positive, negative, and disorganized symptoms. Positive symptoms are characterized as an excess or alteration of everyday, normal functions, such as hallucinations, delusions, and disorganized behavior or speech. Negative symptoms are classified as the absence of typical functioning such as anhedonia (lack of ability to feel pleasure), avolition (lack of motivation), alogia (poverty of speech) or asociality (lack of interest in socializing).

Considered to be one of the most disabling psychiatric diseases worldwide (Rössler, Joachim Salize, van Os, & Riecher-Rössler, 2005), schizophrenia affects roughly 0.3-1.6% of people in the United States (Kessler et al., 2005). This disability is due in part to the severe nature of the positive and negative symptoms, which often result in a profound disruption of many fundamental human capacities such as cognition, memory, language, emotion, perception, and sense of self (APA, 2013). Consequently, many people with the disorder need intensive treatment and care, are unable to hold a full-time job (Salkever et al., 2007), and do not live independently (Folsom et al., 2005). This disability therefore creates a large financial and emotional burden that reaches far beyond the individual, onto his/her family, and often further into the community (Rössler et al., 2005).

The psychosis spectrum. As mentioned above, schizophrenia is one disorder that belongs to a larger psychosis classification of disorders characterized by their prominently psychotic symptomatology. Current dimensional research suggests that psychosis is not a categorical "all-or-nothing" disorder. Rather, a wide range of psychosis-symptom severity exists causing a dimensional conceptualization of the disorder on a severity continuum. The psychosis phenotype is frequently expressed at sub-clinical levels and in the absence of a formal psychotic-disorder (Kwapil & Barrantes-Vidal, 2015). Sub-clinical, or attenuated, psychotic symptoms are

still characterized by hallucinations or delusion-like experiences; however, they present as less formed with the individual expressing less conviction as to their reality. Frequently they are not functionally impairing or distressing to the individual and may even be transient in nature. People with these psychosis-like experiences (PLEs) often have many of the same correlates of symptoms as people with full psychosis, suggesting a continuum of experiences across the population (Arango, 2011).

The prevalence of PLEs in community populations ranges from 5%-8% (van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009), with a lifetime risk of 7.8% (McGrath et al., 2016), thus affecting considerably more people than the approximately 0.3-1.6% that experience schizophrenia. Although all groups along the continuum are heterogeneous in nature, etiological research has uncovered numerous links between people with PLEs and those with psychosis. Van Os et al. (2009) conducted a comprehensive review and meta-analysis of the psychosis continuum and reported substantial shared demographic, genetic, socioenvironmental, and psychopathological risk factors across all psychosis-symptom severity classes. This considerable overlap demonstrates validity for the concept of a continuum beyond surface-level symptomatic expressions. In such a continuum conceptualization, all levels of psychosis severity have a common developmental pathway characterized by psychometrically detectable subclinical psychotic experiences. The majority of the time these symptoms remain mild or transient; however, in roughly 8-10% of those with initially subclinical symptoms, the symptoms persist and progress to a more severe psychotic presentation (Kaymaz et al., 2012).

Focusing research efforts, therefore, on population's exhibiting psychometrically detectible subclinical psychotic symptoms allows for not only a more comprehensive understanding of these individuals, but also may further provide information relevant to those

presenting on the more severe side of the continuum. Furthermore, regardless of their association with psychosis, or the possibility individuals may later develop a more severe form of expression, examining PLEs is clinically meaningful in its own right as they alone are associated with distress and impairments in functioning (Kelleher et al., 2014; Yung et al., 2005), help-seeking behavior (DeVylder et al., 2014), and thoughts or actions of self-harm (DeVylder et al., 2015; Kelleher et al., 2013).

Health Status along the Psychosis Spectrum

The disability and burden associated with schizophrenia is exacerbated by high rates of comorbid mental and physical disorders (Laursen, Nordentoft, & Mortensen, 2014). Buckley et al. (2009) reported substance abuse as the most common comorbid psychiatric disorder followed closely by depression and anxiety disorders. Additionally, a large epidemiological study conducted by Carney et al. (2006) reported a significant increase in physical conditions in every system of the body for patients with schizophrenia, but most noted were congestive heart failure, stroke, neurological disorders, diabetes, obesity, and general cardiovascular conditions.

These physical disorders are the result of both primary and secondary symptoms of schizophrenia as well as side effects from common psychotropic treatments. Positive and negative primary symptoms often lead to sedentary behavior, a known correlate of many metabolic diseases; while secondary symptoms such as high rates of smoking also cause numerous negative health effects (de Leon & Diaz, 2005). Side effects of current psychotropic treatments often lead to as much a decline in physical health as they do improvement in mental functioning, as both typical and atypical antipsychotic medications have significant associations with weight gain and other metabolic diseases (Allison et al., 1999). Consequently, those with schizophrenia have much higher than average mortality rates with a life expectancy of twenty

years less than those without the disorder (Laursen et al., 2014). Notably, this early mortality is more likely to be due to natural causes, such as physical health deterioration, than high-risk behaviors, such as violence or suicide. In fact, people with schizophrenia have significantly lower rates of mortality attributed to unnatural causes (i.e., suicide, homicide, and accidents) relative to any other group with a severe mental health disorder (Laursen, Munk-Olsen, Nordentoft, & Mortensen, 2007).

Health status is similarly affected in individuals experiencing sub-clinical psychotic symptoms. A large, multi-national epidemiological study, using the World Health Organization's World Health Survey reported that PLEs are clearly associated with lower physical health across multiple domains (Nuevo et al., 2010). Health appears to be impacted by PLEs in a dose-dependent fashion, as there is not only a significant difference in health status between individuals experiencing zero PLEs and those reporting one symptom, but this effect is linearly continuous, with each additional psychosis-like symptom resulting in a significantly more deleterious health consequences. Separate reports from this World Health Survey sample extend these findings to report: 1) a similar dose-response relation between severity of PLEs and increases in disability (Navarro-Mateu et al., 2017); and 2) that the association between PLEs and physical health is independent of a mental disorder diagnosis, such that health problems were more frequent in those with PLEs than with a psychotic disorder (Moreno et al., 2013). Additionally, in a large non-clinical sample of youths, Calkins et al., (2014) found that adolescents reporting PLEs had significantly higher odds of comorbid psychiatric disorders, most notably depression, mania, anxiety, and behavioral disturbance. This study, as well as Mollon et al. (2016) also report significantly higher levels of neurocognitive deficits within this sub-threshold population.

Health and overall quality of life appear to be diminished in individuals along the entire psychosis spectrum (van Os, Hanssen, Bijl, & Ravelli, 2000). Such findings highlight the considerable public health relevance of both florid and sub-clinical psychotic experiences.

Physical Activity along the Psychosis Spectrum

Schizophrenia and physical activity. Sedentary behavior is a major contributor to the overall poor health status of patients with schizophrenia (Vancampfort, Probst, Knapen, Carraro, & De Hert, 2012). This population often displays very low PA levels as a result of both the disorder itself and the side effects from treatments (i.e., antipsychotics). Vancampfort et al (2012) used self-report to find that patients with schizophrenia spend roughly 8.5 hours a day sitting in comparison to only 6.21 hours in healthy controls. Similarly, Ratliff et al. (2012), also using self-report, found lower levels of physical activity in those with schizophrenia with the most marked distinction in activity levels between the two groups within the "moderate" activity phase, over "light" or "vigorous." As a methodological advantage, assessing activity in such intensity ranges as employed by Ratliff and colleagues allows for a more comprehensive evaluation of activity patterns and may be useful when interventions to improve these behaviors are created and implemented.

Subjective self-reports, while important, are also collected retrospectively and thus subject to recall biases. Recall bias is an especially salient issue in the schizophrenia population, as impairments in cognition and memory are common. However, objective activity monitoring methods generally corroborate the subjective findings. Using actigraphy watches, Wichniak et al. (2011) found that adult patients with schizophrenia had significantly lower average 24-hour activity levels, lower average daytime 10-hour activity levels, and higher time spent in bed. Lindamer et al. (2008) found adult patients with schizophrenia had significantly lower levels of

light activity in comparison to healthy controls, and "trend level" deficits in moderate and vigorous activity levels.

The benefits of physical activity. Recent research suggests unique and important benefits of increasing PA for people with schizophrenia, including positive effects on general physical health, mental health and well-being as well as decreases in schizophrenia symptomatology. Physically, effects are related to expected general physical benefits for any population including better overall aerobic fitness, lower body mass indexes, blood lipids, blood pressure, body composition, and glucose metabolism (Beebe et al., 2005; Gorczynski & Faulkner, 2010; Vancampfort et al., 2009; Vancampfort et al., 2011).

Physical activity also improves mental health indices and health related quality of life in patients with schizophrenia. Similar to the general population, those with schizophrenia who engage in more physical activity experience lower levels of anger, stress, and depressive symptoms in comparison to those who lead sedentary lifestyles (Hassmén, Koivula, & Uutela, 2000). Further, exercise increases psychopathological symptom coping as well as mobility and walking capacity in schizophrenia populations, which in turn has shown to improve quality of life measures (Vancampfort et al., 2012). Importantly, these improvements in overall mental health seem to lead back to increases in PA (Marzolini, Jensen, & Melville, 2009). This cyclic effect points to the possibility of the continuously increasing benefits to overall mental health with a regular activity program.

Important effects on schizophrenia specific symptoms have also been shown as a result of increased PA. Patients with schizophrenia who report mild or moderate activity, also present with reduced positive and negative symptoms (Beebe et al., 2005; Vancampfort et al., 2012). Additionally, Leutwyler et al. (2014) reported a positive association between higher levels of

daily steps and increased neurocognitive functioning (i.e., better processing speeds and better verbal working memory) in adult patients with schizophrenia. These are especially significant improvements since neurocognitive disability can be one of the most functionally impairing symptoms for those with the disorder (Lin et al., 2011).

Given the positive effects PA has shown on physical and mental indices, studies are now examining PA as an intervention, testing whether controlled increases in PA can significantly reduce symptomatology. Outcomes thus far have been mostly beneficial. Randomized controlled trials (RCTs), using various forms of aerobic PA as the main intervention, have assessed its effect on cognitive deficits (Kimhy et al., 2015; Nuechterlein et al., 2016; Pajonk et al., 2010; Scheewe et al. 2013), quality of life/functioning (Battaglia et al., 2013; Browne, Penn, Battaglini, & Ludwig, 2016; Scheewe et al., 2013), and schizophrenia-symptom domains (Acil, Dogan, & Dogan, 2008; Beebe et al., 2005; Gholipour et al., 2012; Pajonk et al., 2010; Scheewe et al., 2013). Despite methodological differences between programs (i.e., varying forms of control programs, length of intervention, type of aerobic activity), results repeatedly indicate positive effects of PA for those with schizophrenia across all outcome domains. Further, recent meta-analyses indicate PA showed significantly more improvement than controls regarding schizophrenia symptom severity (including positive, negative, and general symptoms), quality of life, and global functioning (Dauwan, Begemann, Heringa, & Sommer, 2015; Firth, Cotter, Elliott, French & Yung, 2015), as well as improvements in cognitive functioning (Firth et al., 2017).

Subthreshold psychosis and physical activity. Current data clearly suggest sedentary behavior is increased in people with schizophrenia, and that increases in PA have multiple positive effects on both psychosocial and neurocognitive domains. Despite strong support for

higher levels of sedentary behavior in those with schizophrenia, there is currently very little information on patterns and levels of PA within the population presenting with sub-threshold psychosis symptoms.

To date, four studies have examined activity levels or attitudes of activity among people with attenuated levels of psychotic symptoms (Deighton & Addington, 2015; Hodgekins et al., 2015; Koivukangas et al., 2010; Mittal et al., 2013). Three of the four studies were cross-sectional in nature, and assessed the PA levels of individuals determined to be at clinical high-risk (CHR) for psychosis. Deighton & Addington (2015) used self-report measures on physical activity and interest in engaging in activity to report that not only do individuals at CHR engage in less PA than healthy controls, but they also perceive less benefit of exercise and more barriers to engage. Hodgekins and collegues (2015), also using self-report measures, noted that individuals at CHR spend less time in structured PA and that this was associated with higher levels of social withdrawal. Mittal et al. (2013) objectively measured PA levels in individuals at CHR using actigraphy monitors. They also found lower overall activity levels in comparison to healthy controls, and these activity levels were similar to, though less sedentary than, what you may see in adults with schizophrenia.

Finally, in a longitudinal population based study in Finland that tracked participants from birth to young-adulthood, Koivukangas et al. (2010) found that those who reported more subthreshold psychosis symptoms were more physically inactive than subjects with few or no symptoms. Further, those who later developed psychosis had three to four times less reported activity before onset than those who did not develop psychosis.

Although informative, these studies have methodological limitations leaving unanswered questions. First, other than Mittal et al., (2013), the studies all relied on retrospective self-report

data for measures of PA, a methodology known to be subject to recall bias. Second, all focused on a psychosis-spectrum group thought to specifically be "at-risk" for psychosis development rather than a group simply displaying PLEs. Though both groups are considered part of the psychosis spectrum, those at CHR are help-seeking, often display more severe symptomatology, and are generally more diagnostically well-defined (Binbay et al., 2012; Kelleher et al., 2012; McGlashan, Walsh, & Woods, 2010). All people at CHR present with PLEs but not all people with PLEs are at CHR. This is an important distinction, as those with PLEs who are not at CHR are much more prevalent in the population, but are often underrepresented in the research. Nonetheless, they are important to study as they serve as a relevant population reference for high-risk research. Due to the underlying common developmental pathways between all individuals on the spectrum, individuals with PLEs in the general population signify an accessible and suitable access point for epidemiological research into the pathophysiology of psychotic symptoms (Fusar-Poli, Nelson, Valmaggia, Yung, & McGuire, 2014).

Research needs to be completed in order to extend physical activity findings to the larger population determined to be on the spectrum. The existing research, although informative, is not methodologically complete. Actigraphy studies lack situational context, and although retrospective reports can provide valuable information, they are known to suffer from biases that impact validity. Knowledge regarding levels and intensities of PA within those who report PLEs would serve to improve understanding of health correlates within this population. Such information thus has the potential to inform lifestyle interventions aimed at increasing activity and decreasing sedentary behavior.

Ecological Momentary Assessment

Precise PA assessment strategies are necessary to provide a valid and comprehensive overview of PA levels. Although previously used subjective and objective PA tracking methods (outlined above) have their strengths, there are nonetheless some discrepancies between outcomes. A method of PA monitoring that minimizes recall bias while still allowing for assessment of valuable environmental or psychosocial associations is needed.

Ecological Momentary Assessment (EMA) fits this methodological gap as it is a longitudinal approach involving mobile monitoring of daily behavior and experiences through a real-time, real-world assessment strategy (Shiffman, Stone, & Hufford, 2008). EMAs collect self-report data multiple times per day through prompt and response methods. When implemented on an electronic device (e.g., smartphone, palm pilot, etc.) EMAs first alert, and then allow, participants to respond to brief questionnaires in the moment. These devices record participant responses and link each response to the precise time answers were submitted (Palmier-Claus et al., 2011). Through these methods, EMAs increase ecological validity, avoid biased retrospective recall, accurately depict temporal relations, and permit assessment of the experience within its daily context (Kimhy, Myin-Germeys, Palmier-Claus, & Swendsen, 2012; Shiffman et al., 2008).

As EMA collects data *in vivo*, it is very sensitive to situational experiences and can therefore capture contextual information that is often unobtainable within a laboratory-based setting (Hofmann & Patel, 2015; Koren, Seidman, Goldsmith, & Harvey, 2006). Also, performance frequently differs between forced laboratory settings, and free, real-world settings. When in a laboratory, participants are removed from their daily lives and thus often their usual emotional experiences and activities. This “distance from life” can promote a subjective

perspective that may alter responses (Weick, 1968). EMA removes this subjectivity as it collects the data within the natural setting.

Additionally, when responding within a laboratory setting, questionnaires used to collect data often use retrospective recall methods. Even thorough retrospective reports are known to be subject to recall bias due to the selective nature of human memory (Tourangeau, Rips, & Rasinski, 2000). Those who are experiencing cognitive deficits, including many individuals with mental illness, are even more likely to experience issues with accurate event recall (Koriat & Goldsmith, 1996). Thus, when assessing those with cognitive impairments, such as people who are experiencing PLEs, this issue may become especially salient. EMA, however, allows accurate collection of self-report data regardless of cognition as it collects it in real-time and minimal to no retrospective recall is necessary.

EMA methods and the psychosis spectrum. EMA methods have been successfully used in people with schizophrenia as well as people at CHR who are in both inpatient (Kimhy et al., 2006) and outpatient (Ben-Zeev, Morris, Swendsen, & Granholm, 2012; Granholm, Loh, & Swendsen, 2008; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001; Palmier-Claus et al., 2012) settings. The technology has been shown to be a feasible, valid, and reliable method to collect daily behavior and symptom data (Granholm, Loh, & Swendsen, 2007; Oorschot, Kwapil, Delespaul, & Myin-Germeys, 2009). However, few studies have used EMA within community settings to assess sub-threshold psychotic experiences.

Verdoux et al. (2003) used paper and pencil EMA techniques with non-help-seeking undergraduates who endorsed high levels of PLEs and reported a positive association between increased PLEs and social interactions with unfamiliar people. Husky et al. (2004) also using paper and pencil EMA with non-help-seeking undergraduates, found PLEs to predict an

interaction between mood states and social environments in daily life. In a help-seeking population high in symptoms of paranoia, though to a degree below psychosis threshold, Collip et al. (2011) used paper and pencil EMA and reported that experiences of paranoia were not significantly associated with environmental familiarity. Additionally, in a large group of undergraduates presenting with heterogeneous schizotypy, a construct similar to PLEs, Kwapil et al. (2012) utilized electronic EMA methodology delivered on a hand-held palm-pilot to measure daily presentation of positive and negative sub-threshold psychosis-dimension symptoms. Findings supported ecological validity of positive and negative schizotypy dimensions. These studies all suggest feasibility of EMA within a college sample experiencing sub-threshold psychotic experiences.

Central to the present study, EMA has been tested together with objective activity monitoring methods and been shown to be a valid and reliable means of assessing physical activity (Marszalek, Morgulec-Adamowicz, Rutkowska, & Kosmol, 2014). Further, a recent review exploring the gold standards and needed future directions of physical activity research suggested EMA as an exemplary methodology for collecting valid and timely self-report PA data (Lewis, Napolitano, Buman, Williams, & Nigg, 2017). No study to-date, however, has used EMA to track physical activity levels within a population experiencing sub-threshold PLEs.

Summary of the Literature

Conceptualization of psychosis on a symptom severity continuum has recently been supported by findings of high rates of people presenting with sub-threshold, non-clinical psychosis symptoms (PLEs). Sedentary behavior and low physical activity are very common in people with psychotic disorders, which is detrimental to both physical and mental health domains. Even modest increases in physical activity have been associated with improvements in

metabolic conditions and psychosis-specific symptoms. However, research on levels of activity within individuals experiencing sub-threshold psychosis is preliminary and further research that measures PA in this population within the community setting could help to clarify these important health correlates. EMA is an ideal assessment tool to collect these data as it allows for the collection of ecologically valid, real-time participant responses with minimal recall bias. A better understanding of the levels of PA throughout the psychosis-spectrum would serve to improve the field's understanding of the clinical presentation of these individuals and ultimately may lead to advances in lifestyle interventions.

Current Study

The purpose of this study is to evaluate whether an association exists between physical activity levels and PLEs among a sample of undergraduate students. More specifically, the study will employ EMA methods to capture daily PA patterns and daily PLEs over the course of one week in individuals representing a range of PLE severity. Aggregate weekly PA scores and aggregate PLE level scores will both be calculated and associations between these scores will be assessed. Due to the importance of studying PLEs outside of help-seeking populations, a college sample is well-suited for this investigation.

Study Aim and Hypothesis

Aim. Assess possible associations between various levels of physical activity and levels of sub-threshold psychotic experiences within college students. The aim of the current study is to determine if there is an association between physical activity level and level of PLEs. Specifically, activity will be measured via EMA, six times a day, for one week and quantified as sedentary, light, moderate, or vigorous. Additionally, an overall total weekly activity score will

be calculated by creating a continuous variable using weighted subdomain activity scores (Committee, 2005). Total weekly activity levels for each of subdomains and overall activity will be calculated. PLEs will similarly be obtained through daily EMA, and total weekly levels of PLEs will be calculated.

Hypothesis. It is hypothesized that significant associations will exist between all sublevels of activity (sedentary, light, moderate, and vigorous) and level of PLEs as well as between total PA and level of PLEs.

Although EMA allows for the interesting collection of moment-to-moment, context specific data, the use of multilevel modeling (MLM) needed to analyze these data is outside the scope of this current study.

Methods

Participant Recruitment and Eligibility

Participants were University of Maryland, Baltimore County (UMBC) students, between the ages of 18-25 years, currently enrolled in a psychology course. To be considered for participation, participants must have a smartphone compatible with the SurveySignal program (the main data collection software), and must not have a disability preventing normal walking or physical activity, as it can be reasonably assumed that an inability to engage in physical activity could alter the outcome of the physical activity measure. The final sample to complete the EMA portion of this study (n = 45) was 57.8% female, with a mean age of 20.41 (SD = 1.66) years.

Sampling

Two phases of sampling, a screening phase and an EMA phase, were employed. The screening phase was used in order to gather baseline data on level of sub-threshold psychotic experiences using the PRIME Screen-Revised with distress (PRIME WD, see Measures below), an adapted screen to assess for the presence of attenuated psychosis symptoms, and any associated distress. Following the screen, a stratified random sampling approach was used for EMA sampling to ensure maximum variability in regards to sub-threshold psychotic experiences. Four separate sampling strata were formed based on frequency distributions of PLEs within the initial screening sample, with four equal sized quartiles created based on PRIME WD symptom scores. Upper and lower score boundaries for each quartile were used to determine data-driven symptom boundaries for each of the current studies four recruitment strata.: a) low level (quartile 1, PRIME WD scores = 0-19), b) medium-low level (quartile 2, PRIME WD scores = 20-32), c) medium-high level (quartile 3, PRIME WD scores = 33-50), and d) high level (quartile 4, PRIME WD scores = 51+). A minimum of 10 participants were recruited from each quartile to participate in the EMA portion, attempts were made to recruit equal numbers of males and females within each quartile (See Figure 1 for sampling flow chart)[1].

Participants for the screening phase were recruited from the UMBC student research pool (Sona System). As part of UMBC's undergraduate program, the Department of Psychology organizes an ongoing pool of possible research volunteer participants from diverse academic majors. Participants were compensated for their time with course extra credit provided by their professors. Interested volunteers who enroll were screened and consented online, through Sona.

[1] During study conception, in order to expedite EMA recruitment, it was proposed to create sampling strata score profiles using pre-collected data from the YouthFirst Lab's Study of Behavior and Personality Characteristics, a study with an anticipated similar population profile, which also assessed PLEs using the PRIME WD. As a result, however, of unexpected interest in the screening phase, and thus rapid levels of recruitment, using pre-collected data was determined unnecessary.

Those who meet inclusion criteria completed a brief, 10-minute, initial questionnaire battery online via a Qualtrics survey, which included the PRIME WD.

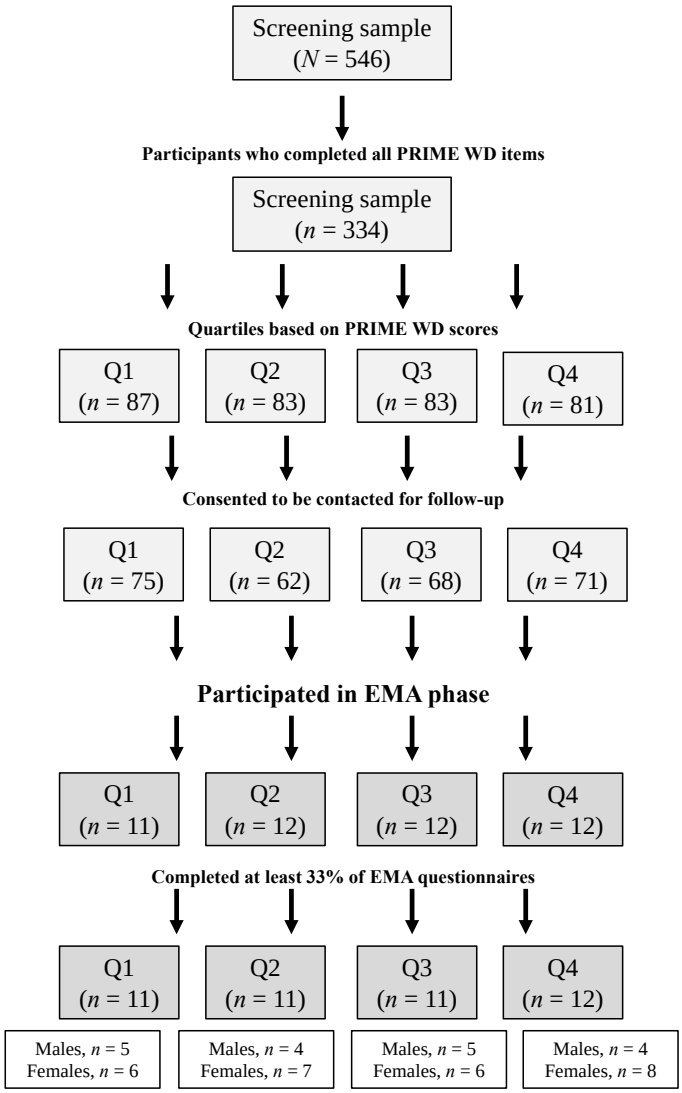

Figure 1. Chart outlining recruitment and sampling procedures.

Recruitment for the EMA phase began after completion of the screening portion, once level of PLEs were determined. Participants were invited, via email, to participate in the EMA portion of the study. In order for EMA data to be considered complete and valid, a participant must complete at least one-third of their daily questionnaires (Myin-Germeys et al., 2001).

Therefore, recruitment continued until at least 10 participants within each diagnostic quartile had completed at least one-third of the EMA questionnaires.

Of note, these quartiles were used for stratified sampling purposes only. Participants were not classified by quartile during data analysis; rather they were viewed on a continuum.[2]

Procedure

Phase 1: Screening and PLE level determination. Interested participants enrolled in the study through the online Sona System. Eligibility criteria were clearly marked on the study description, and probed through initial questions. Eligible students then received a web-based description of the study and informed consent. Participants indicated agreement to participate by making an "I Agree" selection following informed consent. Participants then completed a short battery of self-report questionnaires in which basic demographics, self and family psychiatric history, and level of sub-threshold psychosis symptoms (PRIME WD) were assessed. This questionnaire took participants on average less than 10 minutes to complete. At the end of the questionnaires, participants were asked (via Agree/Disagree selection) if they may be contacted in the future to participate in the voluntary, Phase 2, EMA portion of the study.

Phase 2: EMA. Baseline and phone registration. Participants for Phase 2, the EMA portion, were recruited from those in Phase 1 who agreed to be contacted. Using scores from PLEs obtained from the PRIME WD during Phase 1, equal numbers of participants were recruited from each diagnostic quartile. Participants were invited to participate through an email

[2] In order to validate recruitment methods, a bivariate pearson correlation was run between Phase 1 PRIME scores and Phase 2 baseline PRIME (the PRIME used for main study analyses), and scores were strongly correlated ($r = .733$, $p < .001$). One would expect scores to change slightly over the course of a few months given the transient nature of PLEs, thus this correlation supports recruitment methods.

containing information on the study, and a link to a Sign-Up Genius website ("SignupGenius", 2017), in which they could select a specific day/time to participate.

On the day selected, participants came to the YouthFirst Lab and underwent an informed consent, during which they received an overview of the procedures, risks, and benefits of the EMA phase. Following consent, participants completed a baseline packet of questionnaires, including an updated PRIME screen. Following questionnaire completion, participants received a detailed discussion of the EMA procedures (See Appendix A for EMA Script) in which they learned how to respond to questionnaires (i.e., the assessment schedule, duration of monitoring, the maximal response time to respond, the typical time it takes to complete every questionnaire, and times when not to respond to questionnaire; Kimhy et al., 2012), the importance of completing as many questionnaires as is safely possible, and details of compensation. During this conversation participants were given a handout on EMA logistics and schedules, which also contained contact information in case of questions or concerns (See Appendix B for EMA Participant Handout). At the end of this discussion, participants registered their phone with the SurveySignal software, which required a brief smartphone compatibility test after which a verification text message is sent to the registered phone, and participants must click on the hyperlink to complete registration and receive future study related text messages. Before leaving, participants signed up for a time to return following completion of EMA to receive compensation.

EMA week. The EMA questionnaire texts were sent six times a day at a random minute within a pre-determined 2-hour time frame. In this stratified random sampling design, the six, 2-hour time blocks were the same within every day and between every subject, however, the exact minute of the text varied. Using this method, the 2-hour time blocks are recognized as a constant

unit of analysis, while the variability of the actual questionnaire minimizes participant memory bias by reducing predictability of the assessment (Shiffman et al., 2008). The 2-hour time blocks were set to: (a) 7:30am-9:30am; (b) 10:00am-12:00pm; (c) 12:30pm-2:30pm; (d) 3:00pm-5:00pm; (e) 5:30pm-7:30pm; and (f) 8:00pm – 10:00pm. If the participant did not click on the initial text hyperlink, a follow-up reminder text message was sent 10 minutes later. If the link was not followed after 20 minutes from the original text message, the link deactivated and the questionnaire was considered missing. This process continued for 7-days, thus allowing for a comprehensive assessment of one complete week.

Follow-up. Upon completion of the week, participants returned to the YouthFirst Lab to participate in a brief (< 5 minute) follow-up appointment. During that appointment, participants completed a questionnaire packet containing an IPAQ-Short, and a questionnaire on their experiences using the EMA. Participants received monetary compensation for participation in Phase 2.

The initial consent and EMA training in office lasted 30-minutes to 1-hour. The mobile questionnaires each took roughly 2-3 minutes, 6-times a day, for 7-days. Participants were compensated for their time and effort: $10 per hour for time spent in the office, and $10 for completion of the EMA portion, with an extra $20 bonus if they missed 8 or less questionnaires, and $10 if they missed 16 or less questionnaires. Total compensation was therefore up to $70 for the entire study.

Materials and Measures

The PRIME. The PRIME is a self-report measure designed to evaluate attenuated psychosis symptoms within the past year (Miller, Cicchetti,, Markovich, McGlashan, Woods,

2004). The screener was developed from the Structured Interview for Psychosis Risk Syndromes (SIPS), a well-established, semi-structured "gold standard" interview for assessing attenuated psychotic symptoms (Miller et al., 2003).

The PRIME screen is designed to measure comparable information as the SIPS in a brief, self-report format. It is a 12-item scale with questions describing a range of attenuated symptoms including: unusual thoughts or delusional ideas, suspiciousness/paranoia, grandiosity, perceptual abnormalities or hallucinations, and general concern about "going crazy". Answers are recorded in Likert-type format consisting of 7 options: 0 = *Definitely Disagree*, 1 = *Somewhat Disagree*, 2 = *Slightly Disagree*, 3 = *Not Sure*, 4 = *Slightly Agree*, 5 = *Somewhat Agree*, and 6= *Definitely Agree*. A screener total PLE score can be obtained by summing all responses, resulting in scores ranging from 0-72.

The initial validation study of the psychometric properties associated with the PRIME screen reported sensitivity of 0.90 and perfect specificity in regard to the diagnoses obtained through the complete SIPS interview (Miller et al., 2004). More recently, in a help seeking adolescent population, the PRIME was shown to have an internal consistency, Cronbach's α, of .88 and test-retest correlation, *r* of .79 (Kline et al., 2012). When comparing the PRIME to other psychosis-risk screeners, the PRIME had 69% accuracy in relation to SIPS diagnoses, and while all screeners had statistically equivalent accuracy, the PRIME had the most balanced sensitivity (0.80) and specificity (0.48) (Kline et al., 2012). An example of the PRIME can be found in Appendix C.

The PRIME with distress (PRIME WD). The PRIME WD is a modified version of the PRIME, adapted by the YouthFirst lab to include probes that assess distress associated with each symptom endorsed. For each of the 12 original items, respondents indicate how much they agree

that the experience causes fear or concern or problems for them. Responses can be *not applicable* or can range from 0 = *definitely disagree* to 6 = *definitely agree*. The PRIME WD was scored by creating one aggregate score that takes both the initial PRIME ratings, as well as the follow-up distress rating into account. All distress scores were summed and added to the original PRIME total score (as described above) making the new total PRIME WD score range between 0-144. In this manner, both the presence and severity of symptoms can be taken into account. Psychometric data for the PRIME WD is not yet available. An example of the PRIME WD can be found in Appendix D.

International Physical Activity Questionnaire – Short Form (IPAQ-Short). The International Physical Activity Questionnaire – Short Form (IPAQ-Short), is a self-report measure used to assess physical activity in adolescents and adults (ages 15-69; Committee, 2005). The measure gathers information across a comprehensive set of domains, including: leisure time physical activity, domestic activities, work-related activity, and transport-related activity. It quantifies activities as either sedentary, light/walking, moderate, or vigorous. Sedentary behavior is categorized as time spent sitting or laying at work, at home, while doing course work and during leisure time. Light activity is categorized as time spent walking at work and at home, walking to travel, or any other walking or light activity done for recreation, sport, exercise, or leisure. Moderate activity is categorized as any activity that takes moderate physical effort and makes you breathe somewhat harder than normal, such as carrying light loads or biking at a moderate pace. Vigorous activity is categorized as all activities that take hard physical effort and make you breathe much harder than normal such as heavy lifting, digging, aerobics, or fast biking/jogging. The IPAQ-Short also specifies only to record those vigorous activities that were completed for at least 10 minutes (Committee, 2005).

The IPAQ-Short gathers information on minutes spent engaging in each of these activities over the past 7 days. It has been tested and shown to be both valid and reliable measure of physical activity in numerous populations (van Poppel et al., 2010). Psychometric data reported from comparison of IPAQ-Short to objective measures of activity within a college-aged sample, specify the IPAQ to have acceptable validity and acceptable reliability across all domains of activity (ICC: vigorous = 0.89, moderate = 0.71, walking = 0.89, and total = 0.86). (Dinger, Behrens & Han, 2006). The current study used the IPAQ-Short in two forms: at baseline and during the EMA phase. The IPAQ-Short can be found in Appendix E.

Demographics. Data were collected on gender, race/ethnicity, age, years of education, and current living situation as well as on eligibility for study participation. The demographics questionnaire can be found in Appendix F.

Psychiatric History. Data were collected on participant psychiatric history as well as on status as consumer of mental health services. The psychiatric history questionnaire can be found in Appendix G.

Family Psychiatric History. Data were collected on family psychiatric history. The family psychiatric history questionnaire can be found in Appendix H.

EMA Questionnaire. Each EMA questionnaire was formatted through Qualtrics mobile questionnaires in previously validated methods for EMA, using visual analog scales and box checking to collect all responses (Granholm, Loh, & Swendsen, 2006). The momentary questionnaire contained a modified mobile IPAQ-Short and PRIME WD. As both questionnaires are intended to retrospectively gather data, minor modifications were required. Specifically, in regards to the PRIME WD, modifications in language were required to specify the participant

should be considering his/her responses in the period of time "since the last questionnaire." In regards to the IPAQ, changes to language indicating participants should respond based on their activities "since the last questionnaire" were added, as well as changes in scale of responses. It was determined that requiring estimation of minutes for each type of physical activity at each questionnaire may introduce user error. Thus, an ordinal scale was introduced to the IPAQ in place of the continuous minutes, such that rather that list a specific number of minutes spent in each activity level, participates were asked to choose amount of time from one of six categories: 1) less than 10 minutes; 2) 10 minutes- 30 minutes; 3) 30 min – 1 hour; 4) 1hour – 1.5 hours; 5) 1.5 hours to 2 hours; 6) More than 2 hours. In order to calculate the total activity variable, weights were applied to the ordinal score. As this ordinal scale remained consistent through all activity sublevel questions, weights should have the same impact as intended with continuous scores. Though neither the IPAQ nor the PRIME WD have been validated for use in such a purpose, other physical activity (Marszaek et al., 2014) and psychosis (Palmier-Claus et al., 2012) questionnaires have, and therefore we foresaw no problems applying them in such a manner.

EMA Questionnaire Tool. The mobile questionnaire was administered using SurveySignal (Hoffman & Patel, 2015), an online application that utilizes the mobile device's own text messaging as a signaling mechanism. It was preprogrammed to send a text message, containing a hyperlink that directed the participant to an online Qualtrics pre-made survey (see Figure 2 for depiction of questionnaire). Once the participant clicks on the link, they left a response time stamp that was recorded on the SurveySignal website. A second time stamp was recorded and sent once the survey was submitted, thus allowing for an accurate temporal representation of the entire assessment process. Assessment time stamps for all participants were

recorded and organized on the SurveySignal platform (see Figure 3). Through this program, secure online data collection using the participant's own smartphone was possible.

Figure 2. Visual of a mock Qualtrics Survey on a mobile device

SURVEY SEGMENT WINDOW. Update Segment Links

Survey ID	DAY	SIG	SegmentStartTime	SegmentEndTime	SurWebAddress	Activity Status
090412175426	1	1	09:00	11:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	1	2	11:00	13:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	1	3	13:00	15:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	1	4	15:00	17:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	1	5	17:00	19:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	1	6	19:00	21:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	2	1	09:00	11:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	2	2	11:00	13:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	2	3	13:00	15:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	INACTIVE
090412175426	2	4	15:00	17:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	2	5	17:00	19:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	2	6	19:00	21:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	3	1	09:00	11:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	3	2	11:00	13:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE
090412175426	3	3	13:00	15:00	http://chicagobooth.qualtrics.com/SE/?SID=SV_a91Mr0IAAzcG9Eg	ACTIVE

Figure 3. Visual of a mock SurveySignal questionnaire storage platform

Data Analyses

Preliminary analyses. Prior to running main analyses, preliminary calculations of total weekly activity scores for each of the sublevels of activity (sedentary, light, moderate, and

vigorous) were completed. These were calculated by creating mean activity scores for time spent in each level across all 7 days.

A total overall activity score was calculated by creating a continuous variable using weighted sublevel mean scores. Weights used were those recommended by the authors (Committee, 2005). Every unit of light activity represents 3.3 units, moderate represents 4.0, and vigorous represents 8.0 weighted units. Each of these weighted sublevel scores were summed to create an overall continuous activity mean score for the study period. Thus, following preliminary analyses, five activity variables were created for use in main analyses: weekly mean of sedentary activity, weekly mean of light activity, weekly mean of moderate activity, weekly mean of vigorous activity, and total activity mean. Attenuated psychosis scores were calculated using the PRIME questionnaire scores collected at EMA baseline. Baseline PLEs were selected for use above PLEs gathered throughout the EMA week due to: 1) EMA PLEs scores were highly positively skewed, 2) baseline PRIME was a previously validated measure, unlike EMA PRIME, and 3) baseline PRIME was collected immediately prior to EMA activity, thus fulfilling methodological criteria for regression analyses. In addition, given that that the PRIME WD remained without validation at time of analysis, the PRIME (without distress) was selected as the most appropriate measure of baseline PLEs.

Primary analyses. This study sought to determine if physical activity levels are associated with levels of PLEs. Pearson-correlations and linear regressions were completed in order to assess this association. Prior to these analyses, assumptions of parametric analyses were run. Independent and outcome variables were checked for normality using skewness and kurtosis measures. All activity variables and measure of PLEs were screened for outliers using plots of

standardized z-scores. All measures were determined to be of acceptable normality and no outliers (z-score>3.29) were found.

Following tests of assumptions, pearson-correlations were run between all levels of activity (sedentary, light, moderate, vigorous, total) and PLEs in order to probe any potential relation between variables.

In order to evaluate if baseline PLEs predicted level of activity, five separate linear regressions were run. Each model regressed PLEs onto mean level of activity, while controlling for gender, age, body-mass index, and drug use.[3] All analyses, including tests of observed power, were completed on SPSS 23.

Missing data. Overall, within participants completing the EMA portion of the study, there is very little missing data in regards to baseline questionnaires, as all individuals completed this portion within the YouthFirst Lab. In regards to body-mass index, however, these data were not collected at baseline, but rather participants were asked at a later date (following EMA participation), via a Qualtrics survey sent through email. Given the nature of this data collection, there is BMI data for only $n = 35$ participants. In regards to EMA questionnaire completion, or total percentage of EMA questionnaires completed by participants, there was a survey response rate of 82.51%, with 35.5% of participants ($n = 16$) completing more than 90% of their questionnaires, and 6.7% ($n = 3$) completing less than 75% of their questionnaires.

[3] Drug use will be included as an exploratory covariate due to its potential relation with both activity level and psychosis-like experiences.

Results

Description of sample. The analysis sample included 45 participants, 57.8% were female, with a mean age of 20.41 (*SD* = 1.66) years. Table 1 displays complete sample characteristics.

Table 1.

Participant characteristics

	Participants		
	n	(%)	*M (SD)*
Age			*20.41 (1.66)*
Gender			
Female	26	57.8	
Male	19	42.2	
Race			
Asian	17	37.8	
American Indian	1	2.2	
Black/African-American	10	22.2	
White/Caucasian	15	33.3	
Other	5	11.1	
Ethnicity			
Hispanic	2	4.4	
Non-Hispanic	42	93.3	
Class Standing			
Senior	18	40.0	
Junior	4	8.9	
Sophomore	14	31.1	
Freshman	8	17.8	
Other	1	2.2	
Drug Use			
Current Drug Use	8	17.8	
Mental Health Service Use			
Present Consumer	6	13.3	
Past Consumer	15	33.3	
BMI			*22.78 (3.11)*

Descriptive statistics for main variables. Through the stratified random sampling approach, maximum variability was attempted in regards to the level of PLEs within the sample. Nonetheless, levels of PLEs did not present the whole range of severity as the mean for PRIME was 11.51 (*SD* = 11.18, range 0-44). In regards to physical activity, participants engaged in

more light (*M* = 2.18) and sedentary (*M* = 3.93) behavior than vigorous (*M* = 1.82) or moderate (*M* = 1.83) activity. In fact, 38.3% of the sample did not engage in any vigorous physical activity during the EMA week, and 38.3% did not engage in any moderate activity, while only 4.3% did not report engaging in light activity. In addition, few participants engaged in routine vigorous or moderate activity. Less than one quarter of participants (24.4%) completed more than three events of vigorous activity during the week, while only 20% completed more than three moderate activity events. See Table 2 for complete descriptive information of main study variables.

Table 2.

Descriptive statistics for main study variables

	n	*M*	*SD*	Range	Skew	Kurtosis
Prime	45	11.51	11.18	0-44	0.99	0.48
Total activity	45	29.07	13.96	5.77- 57.49	-0.25	-0.92
Vigorous activity	45	1.82	1.50	0 – 5.00	-0.06	-1.29
Moderate activity	45	1.83	1.74	0 – 6.00	0.55	-0.53
Light activity	45	2.18	0.52	1.3 – 3.93	1.11	2.33
Sedentary activity	45	3.93	0.71	2.58 – 5.29	0.21	-0.96

Correlation matrix. Table 3 displays the bivariate correlation matrix of main study variables, including attenuated symptoms of psychosis, total activity as well as all sublevels of activity, BMI, and current drug use.

Table 3.

Bivariate correlation matrix of main study variables (N = 45)

Measure	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Psychosis-like experience (*n* = 45)	-							
(2) Total activity (*n* = 45)	-.226	-						
(3) Vigorous activity (*n* = 45)	-.186	.857*	-					
(4) Moderate activity (*n* = 45)	-.140	.563*	.073	-				
(5) Light activity (*n* = 45)	.033	-.134	-.316	.029	-			
(6) Sedentary behavior (*n* = 45)	.086	.011	-.054	.124	-.039	-		
(7) BMI (*n* = 35)	.177	.363*	.227	.336*	-.072	-.107	-	
(8) Drug Use (*n* = 45)	.252	.086	.134	-.015	-.181	-.106	.424*	-

*Denotes significance at alpha level .05 (2-tailed)

Correlations between total activity and sublevels (i.e., vigorous and moderate) were, as expected, quite high: .86 and .56 respectively. PLEs were not significantly correlated with any level of activity, although *r* coefficients were moderate in regards to total activity (*r* = -.23).

Main regression analyses. In order to assess the main study hypothesis that associations will exist between all sublevels of activity (sedentary, light, moderate, and vigorous) and level of PLEs, as well as between total PA and level of PLEs, five regression analyses were completed. In each regression, PRIME collected at baseline immediately prior to EMA data collection was set as the independent variable, predicting the outcome variable of level of physical activity. Each regression controlled for age, sex, BMI, and current drug use. Table 4 displays results for each of the five regression models.

In regards to PLEs predicting weighted total activity for the week, the overall model significantly predicted 38% of variability in physical activity (R^2 = .38, $F(5, 34) = 3.55$, p = .01).

Total physical activity was significantly predicted by PLEs, BMI, and age. Cohen's f^2 effect size for PLEs was .14, representing a moderate effect (Cohen, 1988). Models predicting sublevels of activity (vigorous, moderate, light, and sedentary) were not significant (p = .14; p = .20; p = .14; p = .85 respectively). In regards to observed power and effect size (f^2) of PLEs within these models, predicting: vigorous, power = .33 (f^2 = .08); moderate, power = .27 (f^2 = .06); light, power = .07 (f^2 = .01); and sedentary, power = .08 (f^2 = .01).

Table 4.

Multiple regressions for psychosis-like experiences predicting activity

	Predicting Total Physical Activity					
	R^2		F	*df*		*Sig*
Overall model	.38		3.55	5, 34		**.01**
	B	*SE B*	Beta	t	*Sig*	f^2
Psychosis-like experiences	-0.44	0.19	-.350	-2.26	**.032**	.14
BMI	1.86	0.76	.413	2.45	**.020**	.17
Current Drug Use	-3.41	6.79	-.086	-0.50	.620	.01
Age	-3.13	1.39	-.382	-2.26	**.032**	.14
Sex	3.41	4.64	.119	0.74	.468	.01
	Predicting Vigorous Physical Activity					
	R^2		F	*df*		*Sig*
Overall model	.24		1.84	5, 34		.14
	B	*SE B*	Beta	t	*Sig*	f^2
Psychosis-like experiences	-0.04	0.02	-.270	-1.57	.127	.07
BMI	0.12	0.09	.240	1.29	.206	.05
Current Drug Use	-0.10	0.81	-.024	-1.13	.900	.00
Age	-0.32	0.17	-.360	-1.92	.065	.12
Sex	0.32	0.55	.105	0.58	.564	.01
	Predicting Moderate Physical Activity					
	R^2		F	*df*		*Sig*
Overall model	.21		1.58	5, 34		.20
	B	*SE B*	Beta	t	*Sig*	f^2
Psychosis-like experiences	-0.04	0.03	-.243	-1.39	.175	.06
BMI	0.25	0.11	.425	2.25	**.033**	.19
Current Drug Use	-0.75	1.00	-.145	-0.75	.459	.02
Age	-0.28	0.21	-.260	-1.36	.183	.06
Sex	-0.04	0.68	-.011	-0.06	.954	.00
	Predicting Light Physical Activity					
	R^2		F	*df*		*Sig*
Overall model	.24		1.80	5, 34		.14
	B	*SE B*	Beta	t	*Sig*	f^2
Psychosis-like experiences	0.00	0.01	.076	0.44	.662	.01
BMI	-0.02	0.03	-.143	-0.77	.448	.02
Current Drug Use	0.13	0.27	.090	0.47	.639	.01
Age	0.16	0.06	.537	2.86	**.008**	.38
Sex	0.30	0.18	.296	1.65	.111	.08
	Predicting Sedentary Behavior					
	R^2		F	*df*		*Sig*
Overall model	.06		0.39	5, 34		.85
	B	*SE B*	Beta	t	*Sig*	f^2
Psychosis-like experiences	0.01	0.01	.101	0.53	.600	.01
BMI	-0.01	0.04	-.025	-0.12	.904	.00
Current Drug Use	-0.29	0.39	-.159	-0.75	.459	.02
Age	-0.01	0.08	-.023	-0.11	.912	.00
Sex	-0.24	0.27	-0.18	-0.88	.385	.03

Discussion

The present study used EMA to collect physical activity data (total, vigorous, moderate, light and sedentary activity), six times a day, for one week among $n = 45$ undergraduates at various levels of self-reported PLEs. It was hypothesized that significant associations would exist between all sublevels of activity and level of PLEs. Results partially support study hypotheses. Specifically, after controlling for BMI, drug-use, age, and sex, PLEs significantly predicted 38% of the variance in total physical activity, such that higher levels of PLEs predicted lower levels of PA. Effects were not significant; however, in models for which PLEs predicted sublevels of activity (vigorous, moderate, light, or sedentary). Therefore, although we can report that total overall physical activity was significantly lower for those with higher PLEs, it is unclear what, if any, specific type of activity is driving this association.

These findings extend prior literature on PA in individuals across the psychosis spectrum. Specifically, findings from previous literature suggest that those who fall within the more severe portions of the psychosis spectrum (Deighton & Addington, 2015; Hodgekins et al., 2015; Koivukangas et al., 2010; Mittal et al., 2013; Vancampfort et al., 2012) experience lower levels of PA. This study suggests those within the less severe, subclinical PLEs population are also less physically active. This is particularly valuable as individuals further along the psychosis continuum are far more likely to be prescribed psychotropic medications with known side-effects related to decreases in activity level and weight gain. Finding a relation between PA and PLEs in a non-pathological sample suggests that the link between PA and the psychosis spectrum is, at least in part, not completely due to psychopharmacological treatments.

In conjunction with existing literature, this study lends support to the notion that lower levels of PA are associated with psychosis across the entire spectrum, regardless of severity of psychosis-symptom presentation. Collectively this body of work suggests that PA represents a feature of the psychosis phenotype that extends across the continuum of symptom severity. When associated features of an illness are present across all stages of expression, they are often considered pervasive and foundational within the illness phenotype, rather than a secondary symptom of the disorder. Therefore, although the mechanisms are unclear, findings add to mounting evidence that sedentary behavior is a core feature of the psychosis phenotype. Further, given evidence from prior studies that increases in PA lead to improvements in schizophrenia-specific symptomatology (Dunham et al., 2015; Firth et al., 2015), as well as associated neurogenesis of the hippocampus (Pajonk et al., 2010), it is conceivable that PA may have a contributory role in symptom expression across the continuum.

In addition to PLEs, both BMI and age significantly predicted total physical activity. Regarding BMI, findings indicate that those with higher BMI's in fact had higher levels of total PA. Although this finding is contrary to much of the preexisting literature on the associations between weight and activity (Ladabaum, Mannalithara, Myer, & Singh, 2014), given that BMI in this sample was lower than previously reported averages for undergraduates (Frank, Andresen, & Schmid, 2004), effects may be driven by individuals with only slightly higher than average BMI. Although purpose of PA was not assessed, individuals who hope to lessen their BMI engage in higher levels of activity (Wing, 1999), and thus there is a possibility this finding was due to intentional efforts. Age was also a significant predictor of total PA, such that those who were younger engaged in more PA than their older peers. These findings are consistent with previous literature, which indicates that undergraduate students tend to spend less time engaging in

exercise as they get older and farther along in their education (Butler, Black, Blue, & Gretebeck, 2004; Huang, Harris, Lee, Nazir, Born, & Kaur, 2003).

Findings regarding the sub-levels of PA were statistically non-significant. Overall regression models, as well as the PLE variable, did not significantly predict any sublevel of PA. Effects within these models, though non-significant, were however in the expected direction, such that higher levels of PLEs related to lower activity levels. It is possible that the null findings were thus due to low statistical power as a result of a small sample size. In the sublevel activity models, statistical power for the single scale (one form of activity only) is limited in comparison to the aggregate total activity variable, which could have contributed to null findings. Nonetheless, effect sizes for PLEs were small in all sublevel activity models (ranging from f^2= .01-.07), suggesting that it would take a much larger sample to reach statistical significance for any once scale.

One possible reason for these small effects is the large number of participants who did not engage in any vigorous or moderate activity throughout the week, and the very few who did engage in routine amounts of either activity type. Such a lack of range in the dependent variable limits the strength of effects, as any association must be driven by those with low and mid-level activity. Regarding light activity, although the majority of participants did engage in light activity or walking, it is possible that any possible effect of volitional walking related activity was mitigated by mandatory walking on campus for class or university-related activities (in other words, everyone was forced to walk equally). The majority of past research highlighting effects of light activity were found in clinical (Ratliff et al, 2012) and non-undergraduate (Mittal et al., 2013) populations. Further, a meta-analysis examining PA behaviors in college students found that college students engage in less walking for leisure than the general public, and use walking

primarily for transportation purposes (Keating, Jianmin, Pinero, & Bridges, 2005). In order to avoid such limitations, future studies should implement methods to ensure variability of both PLEs and PA.

Overall, these results support the prospect of including PA into the etiological models of the psychosis spectrum. By measuring levels of PA *in vivo*, using mobile, real-time EMA methods, these results add to the literature by extending the sedentary phenotype to those experiencing attenuated symptoms of psychosis without help-seeking behavior or notable clinical distress. Moreover, the sample was comprised of university undergraduates, which represents a high-functioning, community sample, who are at peak age of psychosis symptom development (Thompson et al., 2004). As a result, findings are likely applicable to others in the community experiencing PLEs who may be lower functioning and in a less-structured environment, and thus more at risk for low levels of PA.

Limitations. First, caution should be taken when interpreting the results as generalizability is limited due to the small sample of undergraduate college students who participated, who are further all enrolled in a psychology course from the same university. Nonetheless, as previously mentioned, college students represent an important sample as they are at peak age for psychosis symptom development (Thompson et al., 2004). Further, they present a likely lower level of PLEs severity in comparison to the general population, as they are overall a higher-functioning, and often more structured sample than non-college aged peers. Therefore, given significant associations within this sample between PLEs and total activity, there is reason to believe that results will extend to other non-help seeking individuals experiencing attenuated psychosis symptoms.

In terms of variability, the relatively limited range among PLEs and two sublevels of physical activity (vigorous and moderate) may have impacted findings. Specifically, the PLE variable did not reach full range of expression, despite recruitment methods aimed at sampling along the entire sub-clinical psychosis spectrum. This was expected, however, as it would be unlikely to find undergraduate students functioning within a university at extreme levels of PLEs. Although this study sampled from four quartiles of PLEs derived from a larger pool of students, the baseline measure of PLEs, collected immediately prior to EMA participation, was relatively limited in range, as no individuals endorsed psychosis experiences in the top quarter of possible responses on the PRIME measure. This truncated measure may have led to relatively smaller effect sizes found for models predicting sublevels of PA compared to samples showing a full range of PLEs. Further, regarding PA, less than a quarter of the sample completed more than three vigorous or moderate PA events in the week. Overall, college students are known to participate in less formal PA events than non-college attending peers (Keating et al., 2005), thus this finding is not unexpected. Nonetheless, such behaviors likely mitigated the detection of possible associations between these types of activity and PLEs.

The relatively small sample size likely impacted power of the models, possibly reducing the chance of detecting a true association between PLEs and sublevels of activity. The total activity variable was a composite of three different scales, likely contributing to the fact that it remained robust despite sample size limitations. In contrast, the sublevels were individual scales and more vulnerable to sample-size effects. Although this sample is of acceptable size for EMA methods (Csikszentmihalyi, Mehl & Conner, 2012), given the lack of multilevel modeling (MLM) techniques typically used in these analyses (but not employed in the present study), findings were likely affected by the modest sample size. Related, since mean scores from the

week were used in the models, rather than MLM, analyses were unable to account for repeated measures and associated possible sampling error. Results should be interpreted with caution given these statistical limitations.

Finally, although EMA methods reduce recall bias, are ecologically valid (Mehl & Conner, 2012), and are presented as a valid method for collection of PA (Marszalek et al., 2014), they are still subjective accounts. PA measurement is known to be highly affected by individual perception and all subjective methods will therefore include some measurement error. Objective measures, such as actigraphy, are the only methods available to fully eliminate such potential error (Warren, Ekelund, & Besson, 2010). However, actigraphy methods are subject to their own methodological limitations (Lewis et al., 2017), and cannot take into account valuable environmental or psychosocial associations. EMA does minimize recall bias, while still gathering context specific data. Therefore, despite stated limitations, EMA was determined to be the most appropriate method of physical activity collection for the current study.

Strengths and Clinical Implications. This study represents the first of its kind to examine the levels of PA among a group of individuals experiencing attenuated symptoms of psychosis without help-seeking behavior or notable clinical distress. Further, it is one of only a few to not rely on retrospective recall measurement for PA data, but rather use novel technology to collect information in real-time. Using these methods, this study had a response rate of over 80%, considered very high in comparison to other studies using similar methods (Kimhy et al., 2012).

Increases in PA have multiple positive effects on psychosocial, functional, schizophrenia-specific, and neurocognitive domains within populations experiencing more severe psychosis symptomatology relative to the population of interest in this study (Dauwan et al., 2015; Firth et

al., 2015; Firth et al., 2017). Such improvements are also associated with neurogenesis of specific areas in the brain related to disease development and progression (Pajonk et al., 2010). Given that those with less severe, subclinical PLEs also present with poor overall health, impairments in distress and functioning, and neurological deficits (Calkins et al., 2014; Mollon et al., 2016; Nuevo et al., 2010; Ziermans, 2013), increases in PA may potentially play a helpful role in attenuating these deleterious symptoms. As roughly 8% of the general population experiences some form of PLEs, a prevalence much higher than those with more severe symptoms, implications of increased physical activity could affect a considerable portion of the population.

Future directions. Future research with a larger sample could assess the reliability of these findings, and be better suited to assess any potentially smaller effects not detected in the current study. Additionally, future studies could use methods that attempt to maximize variability of both PLEs and levels of PA. Use of such a sample would likely present a clearer picture of the relations between these variables and further elucidate the role of PA along the psychosis phenotype. Similarly, expanding the sample to those in the community outside a university setting would benefit the generalizability of findings.

Use of MLM techniques to better investigate the effects both within and between individuals would be a natural next step to this research. The omnibus models run for this study provided a significant first look at the larger relations between PLEs and activity; however, understanding the day-to-day changes in activity, and any related effects on socioemotional state would be valuable. The EMA questionnaires provide nested data that is best analyzed using MLM (Nezlek, 2012).

Although the current work represents an important first step in highlighting association of lower levels of PA with higher reported PLEs, future studies should gather more clear data on the impact of PA in an experimental environment. A randomized control trial, in which PA is directly manipulated, would minimize external environmental confounds. Such RCT's have been completed in samples experiencing more severe symptoms, and have reported positive outcomes (Firth et al., 2015), but no such trial has been conducted on those who are in the community at the PLE level. Such a study design could also investigate effects on PLEs regarding the type, duration, and frequency of physical activity.

Finally, applying these findings to clinical use, and starting to use activity as a counterpart to preexisting treatments for attenuated symptoms of psychosis could maximize effects of this research. Such interventions already exist for those with psychosis, and are beginning to emerge for those at CHR (Mittal et al., 2017), yet none are validated for use in those with less severe, but still disturbing, symptoms. Although it is hypothetically difficult to implement such interventions given the non-help seeking nature of this population, there is potential to create a prevention-style intervention within communities that could positively impact larger numbers of individuals. Using PA in combination with other factors, to prevent the onset or reduce the impairment from PLEs, regardless of severity, is an ultimate goal of this area of research.

Appendices

Appendix A: Script for describing EMA procedures

EMA Instruction Script

This study requires you to complete 2-3 minute questionnaires on your phone, 6 times a day, for one week. Questionnaires will be sent to you through a text message containing a link. When the link is sent, please click on the link to access the questionnaire. You have 30 minutes from the time of the text to complete the questionnaire before it is considered "missing." If you do not click the link within the first 10 minutes, a follow-up text message will be sent reminding you to complete your questionnaire. One questionnaire will be sent at a random time during every time interval (show time interval page). Please try your best to reply to all questionnaires where you safely can do so. Do not reply if you are driving.

Once completing the questionnaire, please make sure to think ONLY about how you are feeling at that moment or about your experiences since the last questionnaire.

We are asking you questions on your phone because it allows us to collect information about your experiences very close to the time when you actually experienced them. This will help minimize any chance of you forgetting about what you did. The questionnaires will ask you the same questions at different times throughout the day so that we can understand how your experiences are changing from day to day, or even hour to hour.

The questionnaires ask about what you are doing at the moment, your current mood and behavior, as well as activities since the last questionnaire. The first and last questionnaire of each day are slightly longer because they ask about some extra activities.

Each questionnaire will also ask about any upsetting or negative thoughts you may be having, such as wanting to hurt yourself. Many people have experiences such as these, and it is important to answer truthfully, but, know that your responses will not be sent immediately to any study personnel. If endorsed, information will be provided on the screen about numbers to contact to receive access to care or any other needed assistance."

You will be provided financial compensation based on the amount of time spent in the office as well as amount of questionnaires completed. You receive $10 / hour for time spent in the office, $10 for completion of the online questionnaires, as well as an extra $20 bonus if you miss less than 8 questionnaires, and $10 if you miss less than 14 questionnaires. Thus, compensation can be up to $70."

Surveys will be sent starting tomorrow morning.

Sign up participant for SurveySignal (see signup instructions).

We will now register your phone with the online software that sends the texts to your phone. Please note that you will have to enter your cell number and email address, but not your name. We will enter your ID number instead of your name. After joining, you may be sent an email invitation to join the larger SurveySignal study panel, which would allow you to be contacted by other investigators using the software. You DO NOT have to accept this invitation to participate in this study. If you do not accept the invitation, SurveySignal will not contact you once this study is complete.

Appendix B: Handout given to all participants describing EMA methodology

Study of Daily Emotions and Behaviors

youthfirst
Research & Service for a Brighter Tomorrow

Why do I need to answer questionnaires multiple times a day?

It is important to ask questionnaires in real-time because it allows us to collect information about your experiences very close to the moments that they actually occur, which reduces the chance of forgetting them. The surveys ask the same questions at different times throughout the day so that we can understand how your experiences are changing from day to day, or even hour to hour. In brief, it helps us to understand your daily life and your personal 'story' in a way we cannot know about otherwise.

How will it work?

Links to access the questionnaires will be sent to your phone via text message six times a day, for seven days. When the text arrives, please click on the link and complete the associated questionnaire on your phone. When responding, be sure to think only about your experiences since the last questionnaire. When the access link is sent you will have ten minutes to respond, and then a reminder text will be sent. You will have twenty minutes from the original text to complete the questionnaire before the link becomes inactive. Once a link becomes inactive that questionnaire is considered 'missing'.

What type of questions will I be asked?

The surveys will ask a variety of questions regarding your mood, behavior, and activities since the last questionnaire. The first and last questionnaire of every day are slightly longer than the middle questionnaires, however they still include similar topics.

IMPORTANT:

Your mobile responses are NOT sent immediately to study personnel or a treatment provider. They will only be reviewed by a team member at the end of the study week. If you need access to care before this time, please call the UMBC Counseling Center (410-455-2472) or University Police (410-455-5555)

Questions??
Please email Nicole Andorko: jamesn1@umbc.edu

When will I receive the survey signal texts?

Texts will be sent six times a day, at a random time within predetermined intervals. The intervals during which you will receive a text are:

(1) 7:30am – 9:30am
(2) 10:00am – 12:00pm
(3) 12:30pm – 2:30pm
(4) 3:00pm – 5:00pm
(5) 5:30pm – 7:30pm
(6) 8:00pm – 10:00pm

Appendix C: The PRIME Screen

THE PRIME SCREEN

The following screen asks about your personal experiences. It asks about your sensory, psychological, emotional, and social experiences. Some of these questions may seem to relate directly to your experiences and others may not. Please read each question carefully and answer all questions.

Based on your experiences within the past year, please indicate how much you agree or disagree with each statement by circling the answer that best describes your experience.

Definitely disagree	Somewhat disagree	Slightly disagree	Not sure	Slightly agree	Somewhat agree	Definitely agree

Within the past year:	Definitely disagree	Somewhat disagree	Slightly disagree	Not sure	Slightly agree	Somewhat agree	Definitely agree
1. I think that I have felt that there are odd or unusual things going on that I can't explain.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
2. I think that I might be able to predict the future.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
3. I may have felt that there could possibly be something interrupting or controlling my thoughts, feelings, or actions.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
4. I have had the experience of doing something differently because of my superstitions.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
5. I think that I may get confused at times whether something I experience or perceive may be real or may be just part of my imagination or dreams.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
6. I have thought that it might be possible that other people can read my mind, or that I can read other's minds.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
7. I wonder if people may be planning to hurt me or even may be about to hurt me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
8. I believe that I have special natural or supernatural	**0**	**1**	**2**	**3**	**4**	**5**	**6**

gifts beyond my talents and natural strengths.							
9. I think I might feel like my mind is "playing tricks" on me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
10. I have had the experience of hearing faint or clear sounds of people or a person mumbling or talking when there is no one near me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
11. I think that I may hear my own thoughts being said out loud.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
12. I have been concerned that I might be "going crazy."	**0**	**1**	**2**	**3**	**4**	**5**	**6**

Appendix D: The PRIME Screen with distress

The following screen asks about your personal experiences. It asks about your sensory, psychological, emotional, and social experiences. Some of these questions may seem to relate directly to your experiences and others may not. Please read each question carefully and answer all questions.

Based on your experiences within the past year, please indicate how much you agree or disagree with each statement by circling the answer that best describes your experience.

Definitely disagree	Somewhat disagree	Slightly disagree	Not sure	Slightly agree	Somewhat agree	Definitely agree

Within the past year:	Definitely disagree	Somewhat disagree	Slightly disagree	Not sure	Slightly agree	Somewhat agree	Definitely agree
1. I think that I have felt that there are odd or unusual things going on that I can't explain.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
2. I think that I might be able to predict the future.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
3. I may have felt that there could possibly be something interrupting or controlling my thoughts, feelings, or actions.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
4. I have had the experience of doing something differently because of my superstitions.	**0**	**1**	**2**	**3**	**4**	**5**	**6**

When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
5. I think that I may get confused at times whether something I experience or perceive may be real or may be just part of my imagination or dreams.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
6. I have thought that it might be possible that other people can read my mind, or that I can read other's minds.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
7. I often walk with a limp, which is the result of a skydiving accident.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
8. I wonder if people may be planning to hurt me or even may be about to hurt me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
9. I believe that I have special natural or supernatural gifts beyond my talents and natural strengths.	**0**	**1**	**2**	**3**	**4**	**5**	**6**

When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
10. I think I might feel like my mind is "playing tricks" on me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
11. I have had the experience of hearing faint or clear sounds of people or a person mumbling or talking when there is no one near me.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
12. I think that I may hear my own thoughts being said out loud.	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6
13. I have been concerned that I might be "going crazy."	**0**	**1**	**2**	**3**	**4**	**5**	**6**
When this happens, I feel frightened or concerned, or it causes problems for me. N/A	0	1	2	3	4	5	6

Appendix E: Physical Activity Questionnaire

When responding, please think about the activities you do at work or school, to get from place to place, and in your spare time for recreation, exercise or sport.

Vigorous activity = activities that take hard physical effort and make you breathe much harder than normal
Example: heavy lifting, digging, aerobics, or fast bicycling

Moderate activity = activities that take moderate physical effort and make you breathe somewhat harder than normal
Examples: carrying light loads, bicycling at a regular pace, or doubles tennis

Walking = including walking at work, school, and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

1. How many days out of the past 7 days did you do <u>vigorous</u> activities?

☐ **0 Days** ☐ **1 day** ☐ **2 days** ☐ **3 days** ☐ **4 days** ☐ **5 days** ☐ **6 days** ☐ **7 days**

If 0, skip to #2

On those days, how much time did you usually spend doing vigorous physical activities per day?

_____ Hours and _____ Minutes ☐ Don't know / Not sure

2. How many days out of the past 7 days did you do <u>moderate</u> activities?

☐ **0 Days** ☐ **1 day** ☐ **2 days** ☐ **3 days** ☐ **4 days** ☐ **5 days** ☐ **6 days** ☐ **7 days**

If 0, skip to #3

On those days, how much time did you usually spend doing moderate physical activities per day?

_____ Hours and _____ Minutes ☐ Don't know / Not sure

3. How many days out of the past 7 days did you <u>walk</u>? <u>Please only include instances lasting more than 10 min.</u>

☐ **0 Days** ☐ **1 day** ☐ **2 days** ☐ **3 days** ☐ **4 days** ☐ **5 days** ☐ **6 days** ☐ **7 days**

If 0, skip to #4

On those days, how much time did you usually spend walking per day?

_____ Hours and _____ Minutes ☐ Don't know / Not sure

4. Out of the last 7 <u>weekdays</u>, including time spent at work, at home, while doing course work and during leisure time, how many hours on average did you spend <u>sitting</u>? This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

How much time did you usually spend sitting per day?

_____ Hours and _____ Minutes ☐ Don't know / Not sure

Appendix F: Demographics

Are you male or female? ☐Male ☐Female

Date of birth (mm/dd/yyyy)? _____ / _____ / _____

Please select your current class standing:

☐Freshman

☐Sophomore

☐Junior

☐Senior

☐Other_____

Are you Hispanic, Latino, or of Spanish Origin? Please select your ethnicity:

☐Hispanic or Latino, Spanish Origin

☐Unknown whether Hispanic or Latino or of Spanish Origin

☐Not Hispanic or Latino, Not of Spanish Origin

Please select your race/ethnicity (please select all that apply):

☐Asian

☐Alaska Native

☐American Indian

☐Black or African-American

☐White or Caucasian

☐Other Race or Ethnicity Not Listed

☐Unknown Race and Ethnicity

What is your current living situation?

☐Immediate Family

☐Extended Family/Close Friends

☐Living Alone

☐Roommates

☐Other (specify):_____

Do you live on or off campus?

☐On Campus ☐Off Campus

Do you currently own and use a smartphone (i.e., a phone with an operating system that has the ability to connect to the internet)?

☐Yes ☐No

If YES, what type of Smartphone do you have?

☐iPhone

☐Android phone

☐Blackberry

☐Other (specify):_____

Do you currently have a disability that prevents normal walking or physical activity?

☐Yes ☐No

If YES, briefly explain:_____

Appendix G: Psychiatric History Questionnaire

For this survey, please give your *best estimate* of ages and dates where requested.

1. **In the past 2 months, have you received any mental health care?** ___No ___Yes

If you answered YES, within the past 2 months have you participated in:

2. **Psychotherapy?** ___No ___Yes

3. If YES, #sessions per month on average ___

4. **Psychiatric Medication?** ___No ___Yes

5. If YES, Please list below

_____

Medication Name Total Daily Dosage Start Month/Year

_____

Medication Name Total Daily Dosage Start Month/Year

_____

Medication Name Total Daily Dosage Start Month/Year

6. **Other Mental Health Care** (school/other counseling; hospital program)? ___No ___Yes
7. If YES, what type of care? _____
8. If YES, # of sessions per month?_____

9. Before 3 months ago, did you ever receive mental health care? ___No ___Yes

10. If YES, you <u>first</u> received mental health care at what age? ____

11. If YES, for what challenges? _____

12. Did you ever stay overnight in a hospital for mental health care? ___No ___Yes

13. If YES, at what age(s)? ____

14. If YES, for what challenges? _____

15. If you have not received mental health care within the past 3 months, please indicate how strongly you are considering seeking some type of mental health care by <u>circling</u> a number below:

1 2 3 4 5

Not at all Somewhat Very much

16. If you have not received mental health care within the past 3 months and would like care, you would like assistance for challenges with:

- ☐ Attachment problems
- ☐ Attention-related (ADHD)
- ☐ Learning disorder
- ☐ Suicidality
- ☐ Trauma or PTSD
- ☐ OCD

- ☐ Adjustment to stressful event(s)
- ☐ Behavior problems/Aggression
- ☐ Asperger's or Autism-related
- ☐ Depression/Dysthymia
- ☐ Bipolar disorder
- ☐ Other Anxiety or Phobia
- ☐ Eating Disorder
- ☐ Drug or alcohol problems
- ☐ Psychosis
- ☐ Other

_____

Finally, check all psychiatric diagnoses or conditions which you have now or had in the past:

17. CURRENT

- ☐ Attachment problems
- ☐ Attention-related (ADHD)
- ☐ Learning disorder
- ☐ Adjustment to stress
- ☐ Behavior problems (conduct, oppositional)
- ☐ Asperger's or Autism-related
- ☐ Depression/Dysthymia
- ☐ Bipolar disorder
- ☐ Suicidality
- ☐ Trauma or PTSD
- ☐ OCD
- ☐ Other Anxiety or Phobia
- ☐ Eating Disorder
- ☐ Drug or alcohol problems
- ☐ Psychosis
- ☐ Other

_____

18. PAST

- ☐ Attachment problems
- ☐ Attention-related (ADHD)
- ☐ Learning disorder
- ☐ Adjustment to stress
- ☐ Behavior problems (conduct, oppositional)
- ☐ Asperger's or Autism-related
- ☐ Depression/Dysthymia
- ☐ Bipolar disorder
- ☐ Suicidality
- ☐ Trauma or PTSD
- ☐ OCD
- ☐ Other Anxiety or Phobia
- ☐ Eating Disorder
- ☐ Drug or alcohol problems
- ☐ Psychosis
- ☐ Other

_____

REMINDER: Your answers will be evaluated anonymously. If any of the questionnaires in this packet are upsetting to you we encourage you to contact UMBC counseling center (410-455-2472).

Appendix H: Family Psychiatric History Questionnaire

The questions below ask about your family's mental health history. Please keep in mind all those in your family who are *biologically/genetically related* (e.g. biological siblings, grandparents, parents, cousins, etc.). Do not include those who are not genetically related (e.g., adoptive or step- relations).

1. Does anyone in your family have mental retardation/intellectual disability?

☐ No

☐ Yes

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

2. Did anyone in your family have problems with their nerves or emotions?

☐ No

☐ Yes

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

3. Did anyone in your family feel very low for a couple of weeks or more, or have a diagnosis of depression?

☐ No

☐ Yes

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

4. Did anyone in your family attempt or complete suicide?

☐ No

If yes, check *all* that apply:

☐ Yes

☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

5. Did anyone in your family hear voices or have beliefs that seem strange or unreal (e.g. extreme suspiciousness or paranoia)?

☐ No

☐ Yes

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

6. Did anyone in your family have unusual or bizarre behavior or appearance?

☐ No

☐ Yes

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

7. Did anyone in your family have a diagnosis of schizophrenia?

☐ No

If yes, check *all* that apply:		
☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other,

☐ Yes

Specify:_____

8. Did anyone in your family use alcohol or drugs so much that it caused problems (with health, family, job, or police)? Or, go to AA or NA, or have treatment for this?

☐ No

☐ Yes

If yes, check *all* that apply:

☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

9. Was anyone in your family hospitalized for drug or alcohol related problems?

☐ No

☐ Yes

If yes, check *all* that apply:

☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other, Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

10. Was anyone in your family hospitalized for psychiatric problems?

☐ No

If yes, check *all* that apply:

☐ Mother	☐ Half-Sibling(s)	☐ Cousin(s)
☐ Father	☐ Aunt(s)/Uncle(s)	☐ Other,

☐ Yes

		Specify:_____
☐ Sibling(s)	☐ Grandparent(s)	☐ Other, Specify:_____

References

Acil, A., Dogan, S., & Dogan, O. (2008). The effects of physical exercises to mental state and quality of life in patients with schizophrenia. *Journal of Psychiatric and Mental Health Nursing, 15*(10), 808-815.

Allison, D. B., Mentore, J. L., Heo, M., Chandler, L. P., Cappelleri, J. C., Infante, M. C., & Weiden, P. J. (1999). Antipsychotic-induced weight gain: a comprehensive research synthesis. *American Journal of Psychiatry, 156*(11), 1686-1696.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5(5th ed.). Arlington, VA: American Psychiatric Association.

Arango, C. (2011). Attenuated psychotic symptoms syndrome: how it may affect child and adolescent psychiatry. *European Child & Adolescent Psychiatry, 20*(2), 67-70.

Bardo, M. T., & Compton, W. M. (2015). Does physical activity protect against drug abuse vulnerability? *Drug and Alcohol Dependence, 153*, 3-13.

Battaglia, G., Alesi, M., Inguglia, M., Roccella, M., Caramazza, G., Bellafiore, M., & Palma, A. (2013). Soccer practice as an add-on treatment in the management of individuals with a diagnosis of schizophrenia. *Neuropsychiatric Disease and Treatment, 9*, 595.

Beebe, L. H., Tian, L., Morris, N., Goodwin, A., Allen, S. S., & Kuldau, J. (2005). Effects of exercise on mental and physical health parameters of persons with schizophrenia. *Issues in Mental Health Nursing, 26*(6), 661-676.

Behere, R., Arasappa, R., Jagannathan, A., Varambally, S., Venkatasubramanian, G., Thirthalli, J., . . . Gangadhar, B. (2011). Effect of yoga therapy on facial emotion recognition deficits, symptoms and functioning in patients with schizophrenia. *Acta Psychiatrica Scandinavica, 123*(2), 147-153.

Ben-Zeev, D., Morris, S., Swendsen, J., & Granholm, E. (2012). Predicting the occurrence, conviction, distress, and disruption of different delusional experiences in the daily life of people with schizophrenia. *Schizophrenia Bulletin, 38*(4), 826-837.

Binbay, T., Drukker, M., Elbi, H., Tanık, F. A., Özkınay, F., Onay, H., . . . Alptekin, K. (2012). Testing the psychosis continuum: differential impact of genetic and nongenetic risk factors and comorbid psychopathology across the entire spectrum of psychosis. *Schizophrenia Bulletin, 38*(5), 992-1002.

Bjørnebekk, A., Mathé, A. A., & Brené, S. (2010). The antidepressant effects of running and escitalopram are associated with levels of hippocampal NPY and Y1 receptor but not cell proliferation in a rat model of depression. *Hippocampus, 20*(7), 820-828.

Boots, E. A., Schultz, S. A., Oh, J. M., Larson, J., Edwards, D., Cook, D., . . . Okonkwo, O. C. (2015). Cardiorespiratory fitness is associated with brain structure, cognition, and mood in a middle-aged cohort at risk for Alzheimer's disease. *Brain Imaging and Behavior, 9*(3), 639-649.

Browne, J., Penn, D. L., Battaglini, C. L., & Ludwig, K. (2016). Work out by Walking: A Pilot Exercise Program for Individuals With Schizophrenia Spectrum Disorders. *The Journal of Nervous and Mental Disease, 204*(9), 651-657.

Buckley, P. F., Miller, B. J., Lehrer, D. S., & Castle, D. J. (2009). Psychiatric comorbidities and schizophrenia. *Schizophrenia Bulletin, 35*(2), 383-402.

Bustamante, E. E., Williams, C. F., & Davis, C. L. (2016). Physical Activity Interventions for Neurocognitive and Academic Performance in Overweight and Obese Youth. *Pediatric Clinics, 63*(3), 459-480.

Butler, S. M., Black, D. R., Blue, C. L., & Gretebeck, R. J. (2004). Change in diet, physical activity, and body weight in female college freshman. *American Journal of Health Behavior, 28*(1), 24-32.

Cahill, L. S., Steadman, P. E., Jones, C. E., Laliberté, C. L., Dazai, J., Lerch, J. P., . . . Sled, J. G. (2015). MRI-detectable changes in mouse brain structure induced by voluntary exercise. *Neuroimage, 113*, 175-183.

Calkins, M. E., Moore, T. M., Merikangas, K. R., Burstein, M., Satterthwaite, T. D., Bilker, W. B., Mentch, F. (2014). The psychosis spectrum in a young US community sample: findings from the Philadelphia Neurodevelopmental Cohort. *World Psychiatry, 13*(3), 296-305.

Carney, C. P., Jones, L., & Woolson, R. F. (2006). Medical comorbidity in women and men with schizophrenia: a population-based controlled study. *Journal of General Internal Medicine, 21*(11), 1133-1137.

Cohen, J. (1988). Statistical power analyses for the social sciences. *Hillsdale, NJ, Lawrence Erlbauni Associates*.

Collip, D., Oorschot, M., Thewissen, V., Van Os, J., Bentall, R., & Myin-Germeys, I. (2011). Social world interactions: how company connects to paranoia. *Psychological Medicine, 41*(05), 911-921.

Committee, IPAQ Research (2005). Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ)–short and long forms. *Retrieved September, 17*, 2008.

Convertino, V. A., Bloomfield, S. A., & Greenleaf, J. E. (1997). An overview of the issues: physiological effects of bed rest and restricted physical activity. *Medicine andSscience in Sports and Exercise, 29*(2), 187-190.

Craft, L. L., & Landers, D. M. (1998). The effect of exercise on clinical depression and depression resulting from mental illness: A meta-analysis. *Journal of Sport and Exercise Psychology, 20*, 339-357.

Csikszentmihalyi, M., Mehl, M. R., & Conner, T. S. (2013). *Handbook of research methods for studying daily life*: Guilford Publications.

Dauwan, M., Begemann, M. J., Heringa, S. M., & Sommer, I. E. (2015). Exercise improves clinical symptoms, quality of life, global functioning, and depression in schizophrenia: a systematic review and meta-analysis. *Schizophrenia Bulletin*, *42*(3), 588-599.

Deighton, S., & Addington, J. (2015). Exercise practices in individuals at clinical high risk of developing psychosis. *Early Intervention in Psychiatry*, *9*(4), 284-291.

de Leon, J., & Diaz, F. J. (2005). A meta-analysis of worldwide studies demonstrates an association between schizophrenia and tobacco smoking behaviors. *Schizophrenia Research, 76*(2), 135-157.

DeVylder, J. E., Jahn, D. R., Doherty, T., Wilson, C. S., Wilcox, H. C., Schiffman, J., & Hilimire, M. R. (2015). Social and psychological contributions to the co-occurrence of sub-threshold psychotic experiences and suicidal behavior. *Social Psychiatry and Psychiatric Epidemiology*, *50*(12), 1819-1830.

DeVylder, J. E., Oh, H. Y., Corcoran, C. M., & Lukens, E. P. (2014). Treatment seeking and unmet need for care among persons reporting psychosis-like experiences. *Psychiatric Services*, *65*(6), 774-780.

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., ... & Szabo-Reed, A. N. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine & Science in Sports & Exercise*, *48*(6), 1197-1222.

Duraiswamy, G., Thirthalli, J., Nagendra, H., & Gangadhar, B. (2007). Yoga therapy as an add-on treatment in the management of patients with schizophrenia–a randomized controlled trial. *Acta Psychiatrica Scandinavica*, *116*(3), 226-232.

Faulkner, G., & Carless, D. (2006). Physical activity in the process of psychiatric rehabilitation: Theoretical and methodological issues. *Psychiatric Rehabilitation Journal*, *29*(4), 258-266.

Firth, J., Cotter, J., Elliott, R., French, P., & Yung, A. R. (2015). A systematic review and meta-analysis of exercise interventions in schizophrenia patients. *Psychological Medicine*, *45*(7), 1343-1361.

Firth, J., Cotter, J., Carney, R., & Yung, A. R. (2017). The pro-cognitive mechanisms of physical exercise in people with schizophrenia. *British Journal of Pharmacology*.

Folsom, D. P., Hawthorne, W., Lindamer, L., Gilmer, T., Bailey, A., Golshan, S., . . . Jeste, D. V. (2005). Prevalence and risk factors for homelessness and utilization of mental health services among 10,340 patients with serious mental illness in a large public mental health system. *American Journal of Psychiatry, 162*(2), 370-376.

Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine*, *27*(2), 87-96.

Fusar-Poli, P., Nelson, B., Valmaggia, L., Yung, A. R., & McGuire, P. K. (2014). Comorbid Depressive and Anxiety Disorders in 509 Individuals With an At-Risk Mental State: Impact on Psychopathology and Transition to Psychosis. *Schizophrenia Bulletin, 40*(1), 120-131.

Gholipour, A., Abolghasemi, S. H., Gholinia, K., & Taheri, S. (2012). Token reinforcement therapeutic approach is more effective than exercise for controlling negative symptoms of schizophrenic patients: a randomized controlled trial. *International Journal of Preventive Medicine*, *3*(7), 466.

Goñi, A., & Rodríguez, A. (2007). Variables associated with the risk of eating disorders in adolescence. *Salud Mental, 30*(4), 16.

Goodwin, R. D. (2003). Association between physical activity and mental disorders among adults in the United States. *Preventive Medicine, 36*(6), 698-703.

Gorczynski, P., & Faulkner, G. (2010). Exercise therapy for schizophrenia. *Schizophrenia Bulletin, 36*(4), 665-666.

Granholm, E., Loh, C., & Swendsen, J. (2008). Feasibility and Validity of Computerized Ecological Momentary Assessment in Schizophrenia. *Schizophrenia Bulletin, 34*(3), 507-514.

Haapanen, N., Miilunpalo, S., Vuori, I., Oja, P., & Pasanen, M. (1997). Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. *International Journal of Epidemiology, 26*(4), 739-747.

Hassmén, P., Koivula, N., & Uutela, A. (2000). Physical exercise and psychological well-being: a population study in Finland. *Preventive Medicine, 30*(1), 17-25.

Health, U. S. D. o., & Services, H. (1996). *Physical activity and health: a report of the Surgeon General*: DIANE Publishing.

Herman, K. M., Hopman, W. M., & Sabiston, C. M. (2015). Physical activity, screen time and self-rated health and mental health in Canadian adolescents. *Preventive Medicine, 73*, 112-116.

Hillman, C. H., Kramer, A. F., Belopolsky, A. V., & Smith, D. P. (2006). A cross-sectional examination of age and physical activity on performance and event-related brain potentials in a task switching paradigm. *International Journal of Psychophysiology, 59*(1), 30-39.

Ho, F. K. W., Louie, L. H. T., Chow, C. B., Wong, W. H. S., & Ip, P. (2015). Physical activity improves mental health through resilience in Hong Kong Chinese adolescents. *BMC Pediatrics, 15*(1), 48.

Hodgekins, J., French, P., Birchwood, M., Mugford, M., Christopher, R., Marshall, M., ... & Singh, S. (2015). Comparing time use in individuals at different stages of psychosis and a non-clinical comparison group. *Schizophrenia Research, 161*(2), 188-193.

Hofmann, W., & Patel, P. V. (2015). SurveySignal A Convenient Solution for Experience Sampling Research Using Participants' Own Smartphones. *Social Science Computer Review, 33*(2), 235-253.

Huang, T. T. K., Harris, K. J., Lee, R. E., Nazir, N., Born, W., & Kaur, H. (2003). Assessing overweight, obesity, diet, and physical activity in college students. *Journal of American College Health, 52*(2), 83-86.

Husky, M. M., Grondin, O. S., & Swendsen, J. D. (2004). The relation between social behavior and negative affect in psychosis-prone individuals: an experience sampling investigation. *European Psychiatry, 19*(1), 1-7.

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 40.

Kamijo, K., & Takeda, Y. (2009). General physical activity levels influence positive and negative priming effects in young adults. *Clinical Neurophysiology, 120*(3), 511-519.

Kaymaz, N., Drukker, M., Lieb, R., Wittchen, H.-U., Werbeloff, N., Weiser, M., . . . van Os, J. (2012). Do subthreshold psychotic experiences predict clinical outcomes in unselected non-help-seeking population-based samples? A systematic review and meta-analysis, enriched with new results. *Psychological Medicine, 42*(11), 2239-2253.

Keating, X. D., Guan, J., Piñero, J. C., & Bridges, D. M. (2005). A meta-analysis of college students' physical activity behaviors. *Journal of American College Health, 54*(2), 116-126.

Kelleher, I., Connor, D., Clarke, M. C., Devlin, N., Harley, M., & Cannon, M. (2012). Prevalence of psychotic symptoms in childhood and adolescence: a systematic review and meta-analysis of population-based studies. *Psychological Medicine, 42*(09), 1857-1863.

Kelleher, I., Corcoran, P., Keeley, H., Wigman, J. T., Devlin, N., Ramsay, H., ... & Wasserman, D. (2013). Psychotic symptoms and population risk for suicide attempt: a prospective cohort study. *JAMA Psychiatry, 70*(9), 940-948.

Kelleher, I., Devlin, N., Wigman, J. T., Kehoe, A., Murtagh, A., Fitzpatrick, C., & Cannon, M. (2014). Psychotic experiences in a mental health clinic sample: implications for suicidality, multimorbidity and functioning. *Psychological Medicine, 44*(8), 1615-1624.

Kessler, R. C., Birnbaum, H., Demler, O., Falloon, I. R., Gagnon, E., Guyer, M., . . . Walters, E. (2005). The prevalence and correlates of nonaffective psychosis in the National Comorbidity Survey Replication (NCS-R). *Biological Psychiatry, 58*(8), 668-676.

Kimhy, D., Delespaul, P., Corcoran, C., Ahn, H., Yale, S., & Malaspina, D. (2006). Computerized experience sampling method (ESMc): assessing feasibility and validity among individuals with schizophrenia. *Journal of Psychiatry Research, 40*(3), 221-230.

Kimhy, D., Myin-Germeys, I., Palmier-Claus, J., & Swendsen, J. (2012). Mobile Assessment Guide for Research in Schizophrenia and Severe Mental Disorders. *Schizophrenia Bulletin, 38*(3), 386-395.

Kimhy, D., Vakhrusheva, J., Bartels, M. N., Armstrong, H. F., Ballon, J. S., Khan, S., ... & Castrén, E. (2015). The impact of aerobic exercise on brain-derived neurotrophic factor and neurocognition in individuals with schizophrenia: a single-blind, randomized clinical trial. *Schizophrenia Bulletin, 41*(4), 859-868.

Kline, E., Wilson, C., Ereshefsky, S., Denenny, D., Thompson, E., Pitts, S. C., . . . Schiffman, J. (2012). Psychosis risk screening in youth: A validation study of three self-report measures of attenuated psychosis symptoms. *Schizophrenia Research, 141*(1), 72-77.

Knowler, W.C., Barrett-Connor, E., Fowler, S. E., …. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine, 346*(6), 393-403.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., ... & Lancet Physical Activity Series Working Group. (2012). The pandemic of physical inactivity: global action for public health. *The Lancet, 380*(9838), 294-305.

Koivukangas, J., Tammelin, T., Kaakinen, M., Maki, P., Moilanen, I., Taanila, A., & Veijola, J. (2010). Physical activity and fitness in adolescents at risk for psychosis within the Northern Finland 1986 Birth Cohort. *Schizophrenia Research, 116*(2-3), 152-158.

Koren, D., Seidman, L. J., Goldsmith, M., & Harvey, P. D. (2006). Real-world cognitive—and metacognitive—dysfunction in schizophrenia: a new approach for measuring (and remediating) more "right stuff". *Schizophrenia Bulletin, 32*(2), 310-326.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review, 103*(3), 490.

Kwapil, T. R., & Barrantes-Vidal, N. (2015). Schizotypy: Looking back and moving forward. *Schizophrenia Bulletin, 41*(suppl 2), S366-S373.

Kwapil, T. R., Brown, L., Silvia, P., Myin-Germeys, I., & Barrantes-Vidal, N. (2012). The expression of positive and negative schizotypy in daily life: an experience sampling study. *Psychological Medicine, 42*(12), 2555-2566.

Ladabaum, U., Mannalithara, A., Myer, P. A., & Singh, G. (2014). Obesity, abdominal obesity, physical activity, and caloric intake in US adults: 1988 to 2010. *The American Journal of Medicine, 127*(8), 717-727.

Laursen, T. M., Munk-Olsen, T., Nordentoft, M., & Mortensen, P. B. (2007). Increased mortality among patients admitted with major psychiatric disorders: A register-based study comparing mortality in unipolar depressive disorder, bipolar affective disorder, schizoaffective disorder, and schizophrenia. *Journal of Clinical Psychiatry, 68*(6), 899-907.

Laursen, T. M., Nordentoft, M., & Mortensen, P. B. (2014). Excess early mortality in schizophrenia. *Annual Review of Clinical Psychology, 10*, 425-448.

Lewis, B. A., Napolitano, M. A., Buman, M. P., Williams, D. M., & Nigg, C. R. (2017). Future directions in physical activity intervention research: expanding our focus to sedentary behaviors, technology, and dissemination. *Journal of Behavioral Medicine, 40*(1), 112-126.

Leutwyler, H., Hubbard, E. M., Jeste, D. V., Miller, B., & Vinogradov, S. (2014). Associations of Schizophrenia Symptoms and Neurocognition With Physical Activity in Older Adults With Schizophrenia. *Biological Research for Nursing, 16*(1), 23-30.

Lin, A., Wood, S. J., Nelson, B., Brewer, W. J., Spiliotacopoulos, D., Bruxner, A., . . . Yung, A. R. (2011). Neurocognitive predictors of functional outcome two to 13 years after identification as ultra-high risk for psychosis. *Schizophrenia Research, 132*(1), 1-7.

Lindamer, L. A., McKibbin, C., Nonnan, G. J., Jordan, L., Harrison, K., Abeyesinhe, S., & Patrick, K. (2008). Assessment of physical activity in middle-aged and older adults with schizophrenia. *Schizophrenia Research, 104*(1-3), 294-301.

Liu, M., Wu, L., & Ming, Q. (2015). How does physical activity intervention improve self-esteem and self-concept in children and adolescents? Evidence from a meta-analysis. *Plos One, 10*(8).

Marszalek, J., Morgulec-Adamowicz, N., Rutkowska, I., & Kosmol, A. (2014). Using Ecological Momentary Assessment to Evaluate Current Physical Activity. *Biomed Research International*.

Marzolini, S., Jensen, B., & Melville, P. (2009). Feasibility and effects of a group-based resistance and aerobic exercise program for individuals with severe schizophrenia: a multidisciplinary approach. *Mental Health and Physical Activity, 2*(1), 29-36.

McGlashan, T., Walsh, B., & Woods, S. (2010). *The psychosis-risk syndrome: handbook for diagnosis and follow-up*: Oxford University Press.

McGrath, J. J., Saha, S., Al-Hamzawi, A., Andrade, L., Benjet, C., Bromet, E. J., ... & Fayyad, J. (2016). The bidirectional associations between psychotic experiences and DSM-IV mental disorders. *American Journal of Psychiatry, 173*(10), 997-1006.

Miller, T. J., Cicchetti, D., Markovich, P.J.,McGlashan, T.H.,Woods, S.W. . (2004). The SIPS screen: a brief self-report screen to detect the schizophrenia prodrome. *Schizophrenia Research, 70*(Suppl. 1), 78.

Miller, T. J., McGlashan, T. H., Rosen, J. L., Cadenhead, K., Ventura, J., McFarlane, W., . . . Woods, S. W. (2003). Prodromal Assessment With the Structured Interview for Prodromal Syndromes and the Scale of Prodromal Symptoms: Predictive Validity, Interrater Reliability, and Training to Reliability. *Schizophrenia Bulletin, 29*(4), 703-715.

Mittal, V. A., Gupta, T., Orr, J. M., Pelletier-Baldelli, A., Dean, D. J., Lunsford-Avery, J. R., . . . Millman, Z. B. (2013). Physical activity level and medial temporal health in youth at ultra high-risk for psychosis. *Journal of Abnormal Psychology, 122*(4), 1101-1110.

Mittal, V. A., Vargas, T., Osborne, K. J., Dean, D., Gupta, T., Ristanovic, I., ... & Shankman, S. A. (2017). Exercise Treatments for Psychosis: a Review. *Current Treatment Options in Psychiatry*, *4*(2), 152-166.

Moreno, C., Nuevo, R., Chatterji, S., Verdes, E., Arango, C., & Ayuso-Mateos, J. L. (2013). Psychotic symptoms are associated with physical health problems independently of a mental disorder diagnosis: results from the WHO World Health Survey. *World Psychiatry*, *12*(3), 251-257.

Mollon, J., David, A. S., Morgan, C., Frissa, S., Glahn, D., Pilecka, I., ... & Reichenberg, A. (2016). Psychotic experiences and neuropsychological functioning in a population-based sample. *JAMA Psychiatry*, *73*(2), 129-138.

Myin-Germeys, I., van Os, J., Schwartz, J. E., Stone, A. A., & Delespaul, P. A. (2001). Emotional reactivity to daily life stress in psychosis. *Archives of General Psychiatry, 58*(12), 1137-1144.

Nabkasorn, C., Miyai, N., Sootmongkol, A., Junprasert, S., Yamamoto, H., Arita, M., & Miyashita, K. (2006). Effects of physical exercise on depression, neuroendocrine stress hormones and physiological fitness in adolescent females with depressive symptoms. *European Journal of Public Health, 16*(2), 179-184.

Navarro-Mateu, F., Alonso, J., Lim, C. C. W., Saha, S., Aguilar-Gaxiola, S., Al-Hamzawi, A., ... & Degenhardt, L. (2017). The association between psychotic experiences and disability: results from the WHO World Mental Health Surveys. *Acta Psychiatrica Scandinavica*, *136*(1), 74-84.

Nezlek, J. B. (2012). Multilevel modeling analyses of diary-style data. *Handbook of research methods for studying daily life*, 357-383.

Nocon, M., Hiemann, T., Müller-Riemenschneider, F., Thalau, F., Roll, S., & Willich, S. N. (2008). Association of physical activity with all-cause and cardiovascular mortality: a systematic review and meta-analysis. *European Journal of Cardiovascular Prevention & Rehabilitation, 15*(3), 239-246.

Nuechterlein, K. H., Ventura, J., McEwen, S. C., Gretchen-Doorly, D., Vinogradov, S., & Subotnik, K. L. (2016). Enhancing cognitive training through aerobic exercise after a first schizophrenia episode: theoretical conception and pilot study. *Schizophrenia Bulletin*, *42*(suppl_1), S44-S52.

Nuevo, R., Chatterji, S., Verdes, E., Naidoo, N., Arango, C., & Ayuso-Mateos, J. L. (2010). The continuum of psychotic symptoms in the general population: a cross-national study. *Schizophrenia Bulletin*, sbq099.

Oorschot, M., Kwapil, T., Delespaul, P., & Myin-Germeys, I. (2009). Momentary assessment research in psychosis. *Psychological Assessment, 21*(4), 498.

Pajonk, F. G., Wobrock, T., Gruber, O., Scherk, H., Berner, D., Kaizl, I., . . . Falkai, P. (2010). Hippocampal plasticity in response to exercise in schizophrenia. *Archives General Psychiatry, 67*(2), 133-143.

Palmier-Claus, J. E., Ainsworth, J., Machin, M., Barrowclough, C., Dunn, G., Barkus, E., . . . Buchan, I. (2012). The feasibility and validity of ambulatory self-report of psychotic symptoms using a smartphone software application. *BMC Psychiatry, 12*(1), 172.

Palmier-Claus, J. E., Myin-Germeys, I., Barkus, E., Bentley, L., Udachina, A., Delespaul, P., . . . Dunn, G. (2011). Experience sampling research in individuals with mental illness: reflections and guidance. *Acta Psychiatrica Scandinavica, 123*(1), 12-20.

Pang, T. Y. C., & Hannan, A. J. (2013). Enhancement of cognitive function in models of brain disease through environmental enrichment and physical activity. *Neuropharmacology, 64*, 515-528.

Parker, A. G., Hetrick, S. E., Jorm, A. F., Mackinnon, A. J., McGorry, P. D., Yung, A. R., ... & Purcell, R. (2016). The effectiveness of simple psychological and physical activity interventions for high prevalence mental health problems in young people: A factorial randomised controlled trial. *Journal of Affective Disorders*, *196*, 200-209.

Pasco, J. A., Williams, L. J., Jacka, F. N., Henry, M. J., Coulson, C. E., Brennan, S. L., ... & Berk, M. (2011). Habitual physical activity and the risk for depressive and anxiety disorders among older men and women. *International Psychogeriatrics*, *23*(2), 292-298.

Ratliff, J. C., Palmese, L. B., Reutenauer, E. L., Liskov, E., Grilo, C. M., & Tek, C. (2012). The effect of dietary and physical activity pattern on metabolic profile in individuals with schizophrenia: a cross-sectional study. *Comprehensive Psychiatry, 53*(7), 1028-1033.

Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC public health, 13*(1), 813.

Richardson, C. R., Faulkner, G., McDevitt, J., Skrinar, G. S., Hutchinson, D. S., & Piette, J. D. (2005). Integrating physical activity into mental health services for persons with serious mental illness. *Psychiatric Services, 56*(3), 324-331.

Rosenbaum, S., Tiedemann, A., Sherrington, C., Curtis, J., & Ward, P. B. (2014). Physical activity interventions for people with mental illness: a systematic review and meta-analysis. *Journal of Clinical Psychiatry, 75*(9), 964-974.

Rössler, W., Joachim Salize, H., van Os, J., & Riecher-Rössler, A. (2005). Size of burden of schizophrenia and psychotic disorders. *European Neuropsychopharmacology, 15*(4), 399-409.

Salkever, D., Karakus, M., Slade, E., Harding, C., Hough, R., Rosenheck, R., . . . Yamada, A. M. (2007). Measures and predictors of community-based employment and earnings of persons with schizophrenia in a multisite study. *Psychiatric Services, 58*(3), 315-324.

Scheewe, T. W., Backx, F. J., Takken, T., Jorg, F., van Strater, A. C., Kroes, A. G., . . . Cahn, W. (2013). Exercise therapy improves mental and physical health in schizophrenia: a randomised controlled trial. *Acta Psychiatry Scandanavia, 127*(6), 464-473.

Schmitz, N., Kruse, J., & Kugler, J. (2004). The association between physical exercises and health-related quality of life in subjects with mental disorders: results from a cross-sectional survey. *Preventive Medicine, 39*(6), 1200-1207.

Seifert, T., Brassard, P., Wissenberg, M., Rasmussen, P., Nordby, P., Stallknecht, B., ... & Secher, N. H. (2010). Endurance training enhances BDNF release from the human brain. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 298*(2), R372-R377.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review Clinical Psychology, 4*, 1-32.

Smith, J. C., Nielson, K. A., Woodard, J. L., Seidenberg, M., Durgerian, S., Hazlett, K. E., . . . Rao, S. M. (2014). Physical activity reduces hippocampal atrophy in elders at genetic risk for Alzheimer's disease. *Frontiers in Aging Neuroscience, 6*, 61.

Stathopoulou, G., Powers, M. B., Berry, A. C., Smits, J. A., & Otto, M. W. (2006). Exercise interventions for mental health: a quantitative and qualitative review. *Clinical Psychology: Science and Practice, 13*(2), 179-193.

Strassnig, M. T., Signorile, J. F., Potiaumpai, M., Romero, M. A., Gonzalez, C., Czaja, S., & Harvey, P. D. (2015). High velocity circuit resistance training improves cognition, psychiatric symptoms and neuromuscular performance in overweight outpatients with severe mental illness. *Psychiatry Research, 229*(1-2), 295-301.

Ströhle, A., Höfler, M., Pfister, H., Müller, A. G., Hoyer, J., Wittchen, H. U., & Lieb, R. (2007). Physical activity and prevalence and incidence of mental disorders in adolescents and young adults. *Psychological Medicine, 37*(11), 1657-1666.

Ten Have, M., de Graaf, R., & Monshouwer, K. (2011). Physical exercise in adults and mental health status: findings from the Netherlands mental health survey and incidence study (NEMESIS). *Journal of Psychosomatic Research, 71*(5), 342-348.

Thompson, J. L., Pogue-Geile, M. F., & Grace, A. A. (2004). Developmental pathology, dopamine, and stress: a model for the age of onset of schizophrenia symptoms. *Schizophrenia Bulletin, 30*(4), 875-900.

Tourangeau, R., Rips, L. J., & Rasinski, K. (2000). *The psychology of survey response*: Cambridge University Press.

Van Os, J., Hanssen, M., Bijl, R. V., & Ravelli, A. (2000). Strauss (1969) revisited: a psychosis continuum in the general population? *Schizophrenia Research, 45*(1), 11-20.

Van Os, J., Linscott, R. J., Myin-Germeys, I., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness–persistence–impairment model of psychotic disorder. *Psychological Medicine, 39*(02), 179-195.

Vancampfort, D., Knapen, J., De Hert, M., van Winkel, R., Deckx, S., Maurissen, K., . . . Probst, M. (2009). Cardiometabolic effects of physical activity interventions for people with schizophrenia. *Physical Therapy Reviews, 14*(6), 388-398.

Vancampfort, D., Knapen, J., Probst, M., Scheewe, T., Remans, S., & De Hert, M. (2012). A systematic review of correlates of physical activity in patients with schizophrenia. *Acta Psychiatrica Scandinavica, 125*(5), 352-362.

Vancampfort, D., Probst, M., Knapen, J., Carraro, A., & De Hert, M. (2012). Associations between sedentary behaviour and metabolic parameters in patients with schizophrenia. *Psychiatry Research, 200*(2-3), 73-78.

Vancampfort, D., Probst, M., Scheewe, T., Maurissen, K., Sweers, K., Knapen, J., & De Hert, M. (2011). Lack of physical activity during leisure time contributes to an impaired health related quality of life in patients with schizophrenia. *Schizophrenia Research, 129*(2), 122-127.

Van Dyck, D., Teychenne, M., McNaughton, S. A., De Bourdeaudhuij, I., & Salmon, J. (2015). Relationship of the perceived social and physical environment with mental health-related quality of life in middle-aged and older adults: mediating effects of physical activity. *PloS one, 10*(3), e0120475.

VanKim, N. A., & Nelson, T. F. (2013). Vigorous physical activity, mental health, perceived stress, and socializing among college students. *American Journal of Health Promotion*, *28*(1), 7-15.

Verdoux, H., Husky, M., Tournier, M., Sorbara, F., & Swendsen, J. D. (2003). Social environments and daily life occurrence of psychotic symptoms. *Social Psychiatry and Psychiatric Epidemiology, 38*(11), 654-661.

Warren, J. M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N., & Vanhees, L. (2010). Assessment of physical activity–a review of methodologies with reference to epidemiological research: a report of the

exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *European Journal of Cardiovascular Prevention & Rehabilitation*, *17*(2), 127-139.

Weick, K. E. (1968). Systematic observational methods. *The handbook of social psychology, 2*, 357-451.

Wichniak, A., Skowerska, A., Chojnacka-Wojtowicz, J., Taflinski, T., Wierzbicka, A., Jernajczyk, W., & Jarema, M. (2011). Actigraphic monitoring of activity and rest in schizophrenic patients treated with olanzapine or risperidone. *Journal of Psychiatric Research, 45*(10), 1381-1386.

Williams, P. T. (2001). Physical fitness and activity as separate heart disease risk factors: a meta-analysis. *Medicine and Science in Sports and Exercise*, *33*(5), 754.

Wing, R. R. (1999). Physical activity in the treatment of the adulthood overweight and obesity: current evidence and research issues. *Medicine and Science in Sports and Exercise*, *31*(11 Suppl), S547-52.

Yaffe, K., Barnes, D., Nevitt, M., Lui, L.-Y., & Covinsky, K. (2001). A prospective study of physical activity and cognitive decline in elderly women: women who walk. *Archives of Internal Medicine, 161*(14), 1703-1708.

Yung, A. R., Buckby, J. A., Cotton, S. M., Cosgrave, E. M., Killackey, E. J., Stanford, C., ... & McGorry, P. D. (2005). Psychotic-like experiences in nonpsychotic help-seekers: associations with distress, depression, and disability. *Schizophrenia Bulletin*, *32*(2), 352-359.

Ziermans, T. B. (2013). Working memory capacity and psychotic-like experiences in a general population sample of adolescents and young adults. *Frontiers in Psychiatry*, *4*.

Zschucke, E., Gaudlitz, K., & Ströhle, A. (2013). Exercise and physical activity in mental disorders: clinical and experimental evidence. *Journal of Preventive Medicine and Public Health*, *46*(Suppl 1), S1