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EXPERT OPINION

Biopsychology of Physical Activity in People with Schizophrenia: An Integrative Perspective on Barriers and Intervention Strategies

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Abstract: People with severe mental illness such as schizophrenia experience high physical comorbidity, leading to a 15–20-year mortality gap compared with the general population. Lifestyle behaviours such as physical activity (PA) play important roles in the quest to bridge this gap. Interventions to increase PA engagement in this population have potential to be efficacious; however, their effectiveness can be hindered by low participant engagement, including low adherence and high drop-out, and by implementation of interventions that are not designed to compensate for the cognitive and motivational impairments characteristic for this group. Moreover, and importantly, the negative symptoms of schizophrenia are associated with neurobiological changes in the brain, which—based on principles of biopsychology—can contribute to poor motivation and impaired decision-making processes and behavioural maintenance. To increase PA levels in people with schizophrenia, better understanding of these neurological changes that impact PA engagement is needed. This has the potential to inform the design of interventions that, through enhancement of motivation, could effectively increase PA levels in this specific population. Incorporating strategies that address the dopamine dysregulation associated with schizophrenia, such as boosting the role of reward and self-determined motivation, may improve long-term PA maintenance, leading to habitual PA. Consideration of motivation and behavioural maintenance is also needed to impart health benefits such as prevention of chronic disease, which is associated with currently low PA levels in this high metabolic risk population. Taking a biopsychological perspective, we outline the neural pathways involved in motivation that are impacted by schizophrenia and propose strategies for promoting motivation for and PA engagement from adoption to habit formation.

Keywords: exercise, psychosis, autonomous motivation, behaviour change, lifestyle interventions, behavioural maintenance

Introduction

Since the publication of Crider's detailed textbook *Schizophrenia: A Biopsychological Perspective* in 1979,[1] empirical knowledge about the complexities of schizophrenia as a biopsychological condition has advanced immensely. However, a comprehensive understanding of the condition as complex as schizophrenia requires an integration of evidence from various disciplines. Our integrative perspective to this field contributes to evidence that has a potential to address the high rates of physical health comorbidity in people with schizophrenia, resulting in a 20-year mortality gap compared with the general population.[2] This mortality gap is largely due to higher rates of cardiovascular disease, driven by a combination of genetic factors, poor diet, inadequate exercise, smoking, metabolic adverse effects of antipsychotic medications, and health inequalities.[3] Obesity and metabolic disease are major concerns for people with schizophrenia and can lead to unwillingness to take regular medication, relapse, avertable hospitalisation, and further worsening of health.[2]

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Given accumulating evidence highlighting the role of health behaviour such as physical activity (PA) in improving health in this population,[4–6] our intention is to advance the understanding of the connections between findings from biology, behavioural neuroscience and psychology, to design more effective interventions for promoting PA engagement in this high metabolic-risk population. This endeavour is especially important in light of evidence showing that individuals with schizophrenia with comorbid metabolic syndrome or diabetes mellitus experience more severe cognitive deficits than those without increased risk of metabolic syndrome.[7] Understanding the motivational processes underlying PA, and the impact of neurobiology associated with schizophrenia, is vital for informing the design of PA interventions because schizophrenia is thought to be associated with dopaminergic dysregulation, which can significantly impact motivation, cognition, as well as behavioural change.[8,9] Specifically, these altered dopaminergic pathways in the brain lead to impairments in predicting the value of rewards, including salience.[9] Salience is the perceived importance of a stimulus which drives cognition, behavioural activation, and effort-related decision-making, and is therefore a key consideration for understanding motivational processes.[10] Although antipsychotic medications have been suggested to negatively impact cognition through their anticholinergic effects,[11] there is limited evidence to support their impact, positively or negatively, on motivation.[12] As such, in our perspective, we address likely key barriers to PA engagement experienced by individuals living with schizophrenia and provide recommendations for designing psychosocial PA interventions that can effectively target motivational systems, while considering the role of the neural circuits involved in motivation. These processes are highly complex and interconnected, however this reductionistic approach is aimed at enabling an easier translation into the proposed strategies to increase PA engagement in this population.

Current Evidence

The need to increase PA in people with schizophrenia has been incorporated in clinical guidelines,[2] based upon empirical evidence demonstrating positive effects of PA on both physical health and psychiatric symptoms.[13] Specifically, PA interventions have been found to reduce positive, negative and total symptoms, improve quality of life, global functioning and depressive symptoms significantly more than control conditions,[14] and have also been found effective in reducing cardiometabolic disease in this population.[2] People with schizophrenia have lower levels of PA than the general population, with the majority not meeting the recommended PA levels, hampered by poor uptake and high dropout rates.[15] The reasons for insufficient PA are likely to be multifactorial and include psychological factors, such as low mood, stress,[6,16] psychiatric symptoms and social physique anxiety,[5] physical factors such as physical illness and fatigue,[16] the sedative effects of psychotropic medications,[17,18] and environmental factors (eg, access to facilities).[5] However, low motivation for PA is one of the most commonly reported psychological barriers by both people with schizophrenia[19] and by mental health staff.[20] Due to such complexity of factors and challenges associated with PA engagement, effectively increasing motivation for PA can present a challenge, both to clinicians and people living with schizophrenia.

Mechanisms of Action: From Reward-Driven Action Towards Habit Formation

Motivation is a dynamic process that incorporates both reflective (intentional) and more automatic (non-conscious) processes.[21] This distinction is based upon evidence that humans use two memory systems: an automatic system that learns associations through experiences and is largely independent from working memory, and a reflective system that can learn rules based on language and logic following even a single experience when sufficient cognitive capacity is available.[22] Both processes play a unique role across different stages of behaviour change and, combined, have been found to influence PA engagement in other population groups.[23]

The two stages of PA engagement (see Table 1)—initiation (adoption) and maintenance[21]—involve a series of continuous sub-processes, including reward-driven action and goal-directed decision-making (adoption stage), and habit-formation (maintenance stage).[24] Initially, reward-driven action generates motivation by anticipating the reward/positive behaviour (or avoiding a negative outcome), encoding its value, and updating the relative value of reward. This process is followed by more reflective cognitive processes, specifically goal-directed decision-making, which aims for sustained motivation through effort–reward trade-off and effective cognitive control, including skills of delayed planning, retaining the goal, monitoring the performance, and regulating action,[25] to enable pursuit of future goals.[26] Finally, to achieve habit-formation and continuous engagement in PA, sustained motivation and adequate goal-directed decision-making is

Table 1 Compensatory Strategies to Facilitate Behaviour Change Across Two Stages of PA Behaviour Engagement

	Stage of PA Across Time	
Intervention goal:	**Initiation (adoption), days/weeks**	**Habit formation, months/years**
Behavioural level:	Starting with low-effort activities and increasing training and repetition frequency	Long-term sustaining of regular engagement in chosen activities
Psychological level:	Anticipating a reward and choosing an appropriate goal-directed action	Regular engagement of habitual PA with little conscious effort, less dependent on self-control
Types of motivation (regulation):	Extrinsic motivation (from external to integrated regulation); goal-directed	Intrinsic motivation (intrinsic regulation); automatic, habit-directed
Motivational sub-processes:	Reward-driven approach and goal-directed action	Habit formation
Impairments in schizophrenia:	- Impaired reward prediction (negative prediction error) - Temporal discounting - Anticipatory reward deficits - Reduced selection of high-effort activities - Impaired associative learning	- Worsening of symptoms - New barriers - Change in regular routines - Shifts in priorities - Complacency
Main neural circuits:	Ventral (limbic) striatum, anterior cingulate cortex and dorsolateral prefrontal cortex, dorsomedial (associative) striatum	Dorsolateral (sensorimotor) striatum and infralimbic cortex
Compensatory strategies to increase PA:	- Start with low-effort activities and increase their intensity only when positive rewards are more likely - Focus on PA that elicits pleasure and enjoyment, or is fun, considering green spaces, sport and recreation in addition to traditional gym exercise based on preference - Provide constant feedback and frequent and immediate priming with motivating rewards - Offer supervised activities preferably delivered by an exercise professional - Facilitators may encourage reflection on the experience of pleasure resulting from PA when planning future activities - Identify personal motivations (long-term goals), capacities and barriers - Still reinforce frequently with positive feedback and novel rewards and activities, but slowly transition towards planning and establishing a PA routine - Assist with planning exercise sessions, including exercise clothing and food before sessions, transport, use of a weekly calendar - Continue to prompt with social support	- Elicit autonomous motivation to improve computing the reward value of PA and reduce the need for making conscious mental computations of the rewards by habituating the behaviour - Ensure consistent cueing of PA using environmental cues (same time, day, trainer or support worker, favourite music) to make behaviour more automatic and reduce mental load - Provide professional support and plan monitoring strategies - Encourage associating successful engagement in PA with an individual's long-term goals, development of self-talk statements that connect actions to aspirations

Note: The compensatory strategies have been informed by Kesby et al (2021), Conn et al (2021), Kim (2013) and Lally and Gardner (2013).
Abbreviation: PA, physical activity.

required to maintain the target behaviour.[21] This process leads to learning of a specific stimulus–outcome association, through recurring context cues, where activities are performed with less conscious effort and independent of immediate rewards[27] and short-term changes in goals.[28] There are numerous theories explaining the mechanisms behind the role of the above concepts for health behaviour change; we encourage interested readers to seek a more detailed understanding of these theories and processes in a review of behaviour theories[29] or original publications.[27,30–34] Taking an integrative biopsychological perspective, enriched by the clinical and academic experiences of our multidisciplinary authorship

team, this perspective aims to tackle the most encountered barriers to PA in people with schizophrenia and propose strategies for promoting motivation for and PA engagement from adoption to habit formation.

Barriers and Strategies to Adopt and Maintain Physical Activity Behaviour

Broad aims of interventions to promote PA are to: (i) facilitate positive experiences with the target behaviour, (ii) incorporate learning to develop skills and positive attitudes related to the behaviour, and (iii) develop habitual responses involving the behaviour in relevant contexts.[35] However, as mentioned, the barriers to achieving these aims in individuals with schizophrenia are complex,[6,16] reflecting the impairments in the neurobiological pathways underlying motivation in schizophrenia. Specifically, dopaminergic pathways, which play an important role in motivational processes, are impacted in schizophrenia. A recent review concluded that both cortical and subcortical dopamine exhibit a strong influence on a range of cognitive domains, including attention, reward learning, goal-directed action and decision-making.[9] These cognitive impairments are reflected in unique challenges faced by individuals with schizophrenia at adoption and maintenance stages of PA behaviour.

Adoption of Physical Activity Behaviour

Problems with motivation for PA engagement, frequently reported by people with schizophrenia,[16] which in part result from dopamine dysregulation associated with schizophrenia, include altered reward prediction, reduced higher-effort allocation to obtain rewarding experiences, and reduced selection of high-effort alternatives.

Reward Prediction Error

People with schizophrenia commonly underestimate potential positive experiences and benefits of PA. This is partly due to deficits in reward prediction error, which can lead to slower and more difficult reinforcement learning (ie, associating the valuable outcome with the activity that preceded it). Lower reward prediction error impairs the ability to fully encode the rewarding value of PA, and therefore sustains the prior underestimate of the expected reward undermining the adoption of PA engagement.[24] To facilitate uptake of PA in this population, it is therefore paramount to design strategies that compensate for reward prediction error by maximising the reward value of known motivators for PA,[16] for example by highlighting the critical role of regular PA for healthy ageing, preventing functional and cognitive decline, and promoting independent mobility and quality of life—the positive rewards of PA advocated at the general population-level.[36] On the other hand, PA-promoting strategies should minimise the cost and effort involved in doing the activities by choosing the intensity of activities that is appropriate for an individual,[37] to assist encoding and reinforcement learning.

The strategy of maximising the rewards of PA has its rationale in altering the motivational modulation of PA behaviour, which is thought to depend on the limbic striatum.[9] Strategies that would maximise social rewards and positive experiences with PA (eg, doing PA with a group of people will be fun) may stimulate the limbic striatum, which encodes motivational variables that are then used by cortical subregions and the associative striatum to select future actions and encourage repetition of behaviour. Given the dopaminergic dysregulation associated with schizophrenia, it is noteworthy to mention that dopaminergic neurons in the midbrain, which project to the ventral (limbic) striatum, are strongly involved in mediating the rewarding effects of stimuli.[9,38] Importantly, animal and human studies have shown that activation of the ventral tegmental area from hedonic stimuli, such as food and social connection, results in phasic dopamine release to the nucleus accumbens.[39,40]

Therefore, motivation for PA may also be increased through social and hedonic experiences (eg, enjoying exercising with a group of people). As such, when promoting adoption of PA among people with schizophrenia, social rewards could be facilitated by playing a person's favourite music in a welcoming environment either in groups of people who share similar experiences or individually, depending on the preference, with a facilitator who employs person-centred and inclusive approaches.[41] Previous research has highlighted the importance of providing positive and encouraging feedback in learning a new complex behaviour.[42,43] Taking a reward-driven approach, this positive feedback should be provided in close proximity to the PA itself and repeated often in the PA adoption phase, to account for the reinforcement learning deficits associated with schizophrenia.[9] Through frequent repetition of such experiences, and with consistent social and environmental cues, striatal neurons will gradually form associations with these conditioning stimuluses (eg, music, friendly social group) following principles of general reinforcement learning models.[44] Such associations are highly dependent on dopamine signalling in the

striatum, a core part of learning-related circuits. Through this process of reinforcement learning, the formation of action–outcome associations may be purposefully built, which is especially relevant in people with schizophrenia who typically show difficulty in integrating action–outcome learning to guide choice.[9,45]

Temporal Discounting

Another barrier to the adoption of PA in people with schizophrenia is that the incentive value of a stimuli is reduced when the expected reward is delayed (ie, temporal discounting is increased). Such temporal discounting of the reward further conflates problems computing the expected value of a reward.[46] For example, a person with schizophrenia may not perceive the health benefits of PA as valuable due to poor reinforcement learning and may be further discouraged to continue with activities if the goals they have set up are several months away. Similar problems cause impairments in the ability to anticipate pleasure and recall pleasure retrospectively, resulting in less likely engagement in activities based on an expectation that the effort required to engage in activity will not be worth it.[47] Social influences may be helpful to minimise the impact of these disrupted anticipatory reward processes on the likelihood of maintaining the newly adopted activities.[29]

Based on habit theories (eg, Rothman et al, 2009),[21] maintenance of PA may be supported through a supportive environment (eg, easy access to facilities) and positive social connections while exercising, which would lower the perceived costs of the new behaviour, including the amount of decision-making and resources required by an individual.[29] As such, carefully designing activities so they are pleasurable and maximise enjoyment[48] in the adoption phase is essential, and could include diverse strategies such as using fun games, exercising within green spaces,[49] and offering sport and recreation that are closely linked with hedonic experiences.[50,51] To address the anticipatory reward deficits,[21] staff involved in the support of PA adoption could affirm any positive feelings individuals may have after engaging in PA, and later help them to recall and discuss these positive memories when the individual is considering future PA.[52] Further, supervisors and facilitators aware of the negative symptoms of schizophrenia, related to motivational impairments, can ensure that a more reward-driven approach (eg, provide constant feedback and immediate priming with motivating rewards) is adopted during the uptake of activities to reduce high drop-out in this population. During the maintenance of activities, they can also transition to supporting an individual's goal-directed action by assisting more actively with planning a PA routine and strengthening the associations with long-term goals.

Planning Deficits

Executive functions, and specifically planning, have been consistently shown to be impaired in schizophrenia.[53,54] Evidence suggests that impaired executive functioning is associated with reduced activation in the left dorsolateral prefrontal cortex, rostral/dorsal anterior cingulate cortex, left thalamus, and inferior/posterior cortical areas[55] and that planning deficits in individuals with schizophrenia are not task specific, but rather affect central cognitive processes critical for planned behaviour.[56] It is, therefore, likely that motivation for PA in people with schizophrenia is impacted by a deregulation of planning and decision-making. Given an increasing body of evidence that supports the role of specific detailed plans of when, where, with whom, and how people will be active (ie, action planning) and if–then plans that structure PA as part of a routine (ie, implementation intentions)[31] in enhancing motivation and PA behaviour, the observed planning deficits in people with schizophrenia could be addressed by implementing strategies that would involve an individual in formulating specific if–then plans (eg, "when the support worker arrives on Monday morning, it is time for a 30-minute walk").[34] Such strategies may also have the benefit of leading to long-term habits for PA.[57,58]

Further, impaired executive control and planning skills are also hypothesised to be reflected in an individual's self-regulatory capacity, which includes processes of self-monitoring, self-evaluation and self-reinforcement.[29] To support these processes externally, those involved in facilitating PA, such as clinicians, exercise professionals, disability support workers or peer health coaches, may assist individuals with schizophrenia so that PA activities are incorporated explicitly into their daily and weekly schedules, and provide assistance with planning and problem solving regarding transport to PA if required, given this can be a barrier to engagement.[20,42] Regular supervision by an exercise professional such as a physiotherapist or accredited exercise physiologist is likely to be beneficial when individuals become more motivated but have not yet developed habitual PA engagement.[15] At this stage, supervisors can assist with establishing a concrete

plan of activities leading to a specific long-term goal, monitoring progress, or selecting a new strategy or activity to pursue the goal if needed.

Effective monitoring and providing real-time memory aids of planned and scheduled activities could be achieved by the use of digital health interventions, such as mobile apps that use peer community, goal and achievement tracking, along with structured motivational coaching.[59] More recent evidence shows that people with severe mental illness and specifically with schizophrenia are accepting of and willing to use digital health tools like mobile apps for improving care.[60,61] This approach could also be complemented by regular motivational sessions, led by a professional from a health-related field (eg, psychology, physiology, nutrition), where progress towards goals is assessed in the context of PA guidelines and benefits, combined with self-monitoring of PA using fitness trackers providing real-time feedback.[59]

Goal-directed action and associative learning are driven primarily by the dorsomedial (associative) striatum.[9,55] However, in schizophrenia, associative striatal dysfunction compromises goal-directed action, making it difficult to integrate action–outcome learning to guide choice.[9] To elicit more goal-directed control for PA, facilitating self-determined motivation by identifying a person's reasons for wanting to be physically active and goal they want to achieve with PA may boost self-regulatory functioning, and enhance the perceived value of the target behaviour.[62] While the above strategies broadly aim to establish learned context–action associations, which are thought to trigger automatically cued behavioural activities (eg, when a specific music plays or a specific support person arrives at the same time each week, it is time for a specific exercise routine), habit-formation models become more dominant for designing interventions, once the motivation for PA engagement is sufficiently elicited with rewarding experiences and other rewards.[27]

Behavioural Maintenance Towards Habit Formation

Increasing the motivation for PA is crucial during the adoption stage when a person starts engaging in regular PA. At this stage, support requires frequent, novel rewards and planning strategies. In contrast, habitual responding is a self-initiated action less dependent on rewards. The process of habit formation is thought to rely on the activity in the dorsolateral (sensori-motor) striatum, rather than the associative or limbic striatum.[9] As such, to facilitate long-term and habitual PA engagement, it is important to tap into individuals' intrinsic motivations (eg, because it is enjoyable),[63] which may lead to more regular behaviour–reward pairings that can support habit formation.

One way of encouraging maintenance of PA that could lead to habit formation is establishing intervention conditions that are conducive to integration of PA within a person's value system and strengthening autonomous motivation, a concept derived from self-determination theory (SDT).[64] There is growing empirical evidence on the importance of autonomous motivation in adopting and maintaining PA in people with severe mental illness, and specifically in schizophrenia.[65] For an overview of intervention studies in this area and the associations of different motivational constructs, see Farholm and Sorensen.[66] According to SDT, autonomously motivated individuals engage in an activity out of personal interest and satisfaction, experiencing a sense of personal choice and autonomy in pursuing the behaviour, which is not contingent on external demands or incentives. Evidence from studies with people with schizophrenia support the theoretically-predicted pattern of those who engage in regular PA having more self-determined forms of motivation (performing activities out of inherent interest/enjoyment and because it is personally valued).[67] The role of autonomous motivation has also been highlighted in increasing the acceptability of lifestyle (diet and exercise) interventions within a residential rehabilitation setting for people with severe mental illness.[51]

According to SDT, autonomous motivation can be facilitated in environments that promote psychological needs for autonomy (experiencing psychological freedom when engaging in physical activities), relatedness (being socially connected) and competence (feeling effective in doing the exercises or achieving the outcomes).[64] Strategies to increase autonomous motivation for PA (rather than being externally motivated) should facilitate satisfaction of these needs, including using mobile apps or co-design principles, where service users are consulted on their preferences regarding the development and implementation of exercise interventions. In people with schizophrenia with low motivation for PA, clinicians can support their sense of autonomy by using autonomy supportive language (eg, "could", "choose", rather than "should" or "have to"), offering choices around the types of PA, and considering an individual's preferences (eg, individual/group setting). Activities tailored to an individual's current ability and provided with clear instructions may help with strengthening a sense of competency.[68] Based on goal-setting theory, discovering individuals' aspirations for PA and assistance with developing personalised goals is vital; utilising SMARTS goals (specific, measurable, achievable,

realistic, time-bound, and self-determined) has been an established strategy.[68] However, for inactive individuals, prior research has shown that the pursuit of SMARTS goals can lead to reduced pleasure, enjoyment and motivation as well as individuals' efforts to engage in future PA.[69] Goals that are non-specific and focus on the process (eg, "do your best", "see how active you can be"), rather than a specific amount of PA may, therefore, be preferable.

This stage of PA engagement also requires a shift from extrinsic motivation and rewards towards more intrinsic forms of regulation. Behaviour strategies to achieve this shift include encouragement, personalised goal setting, and individualisation of the program to suit an individual's capacities and preferences.[66,70] Exercise professionals and mental health clinicians can play an important role in helping individuals to connect actions with their aspirations to assist with the development of more autonomous motivation. For example, facilitators may assist individuals to reflect on their successes and develop positive self-talk statements, such as "every time I do PA/exercise/sport, I am getting closer to my goal of improving my fitness".[71] To progressively reduce dependence on rewards and other external reinforcement, it is useful to conceptualise optimal behaviour as determined not only by the rewards obtained but also by the minimization of the cost related to a specific set of actions needed to accomplish the action.[72]

A schematic representation of the different stages of PA across time, starting with adoption (days/weeks) and, ideally, leading to long-term maintenance or habit formation (months/years), with associated motivational and neurobiological processes and the proposed strategies to facilitate behaviour change in people with schizophrenia is provided in Table 1. While behaviour change models that are currently applied in clinical practice to increase PA in the general population,[73] and specifically in people with severe mental illness,[74] such as SDT[64] or the transtheoretical model[75] that takes a more macro-level perspective, can be helpful in encouraging individuals in the general population to engage in more PA,[73] the biopsychological perspective on promoting PA in individuals with schizophrenia, depicted in Table 1, adds value to these existing models by highlighting the neurobiological processes that may hinder the efforts of people living with schizophrenia, clinicians, peer support workers, and other carers in facilitating a positive behaviour change (ie, increased PA engagement). We propose that, by understanding the altered dopaminergic pathways in the brain of individuals with schizophrenia that are involved in motivation and behaviour change, the intervention strategies can be tailored to compensate or, through engaging habitual, autonomic processes,[76] to by-pass some of the unique, and pronounced, cognitive and motivational deficits experienced by people with schizophrenia.

Conclusions and Future Directions

While evidence supports the significant benefits of PA on a wide range of domains, people with schizophrenia still engage in insufficient PA to achieve health benefits.[2] Those with high metabolic or cardiovascular risk could especially benefit from increased PA engagement.

Through a biopsychological perspective, we illustrated how neurobiological dysfunction associated with schizophrenia may impact motivation for PA, which can contribute to poor adoption and maintenance of PA behaviour. With this understanding—and acknowledging that our perspective is not based on a systematic review of the literature, but rather presents an integration of key findings from relevant disciplines—it is essential that PA and lifestyle interventions for people with schizophrenia incorporate strategies that enhance motivational processes through maximising the reward value and facilitating satisfaction of the psychological needs of autonomy, competency and relatedness to promote autonomous motivation. When promoting PA in people with schizophrenia, it is important to tailor the intervention targets to an individual's phase of PA engagement. Identifying whether an individual is at the stage of adopting or initiating a PA routine or is already headed towards behaviour maintenance and habit formation can inform clinicians' decision-making regarding the most appropriate motivational processes to target and the relevant behaviour change strategies. Such individualised interventions should be informed by further research into the modifiable mechanisms underlying motivation for PA in schizophrenia, with consideration of different stages of schizophrenia (early/chronic psychosis) and across different settings (eg, in-/out-patient).

Additionally, habit formation theory shows promise in potentially by-passing the prominent negative and other cognitive symptoms that present a challenge to increasing PA, by fostering a cognitively less effortful and, as such, more association-based engagement in PA. To support people with schizophrenia in the formation of habitual PA, it may be helpful to assist with planning to ensure a consistent PA routine is practised regularly and to the point of being

encoded in the memory as motor-cue associations. Future research should test the potential value of habit formation theory and systematically evaluate the potential of specific behaviour change techniques for increasing motivation for and engagement in PA in people with schizophrenia.

Finally, highlighting the recommendation of the Lancet Commission on physical health comorbidity of people with mental illness,[2] the assessment of PA should become complementary to anthropomorphic measurement, to create a prompt need for a multidisciplinary approach to increase PA levels in people with schizophrenia and, thus, to improve their physical and mental health. With clinical guidelines increasingly recognising the need for the assessment of PA within routine clinical care, it may be timely that such assessment would also include a measure of motivation or behavioural regulation in PA which could inform the development of a tailored, person-centred plan to promote autonomous motivation for PA. Our intention is also to highlight the value of PA as a modifiable lifestyle factor which can support schizophrenia treatment, in the hope that the identified strategies to address the known neurobiological challenges of schizophrenia will assist clinicians and people with schizophrenia in increasing PA engagement and contribute to further research of this important health behaviour.

Disclosure

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