





Healthy Eating, Physical Activity, and Sleep Hygiene (HEPAS) as the Winning Triad for Sustaining Physical and Mental Health in Patients at Risk for or with Neuropsychiatric Disorders: Considerations for Clinical Practice

This article was published in the following Dove Press journal:
Neuropsychiatric Disease and Treatment

Matteo Briguglio, ^{1*} Jacopo Antonino Vitale, ¹ Roberta Galentino, ² Giuseppe Banfi,^{1,3} Carlotta Zanaboni Dina,⁴ Alberto Bona,⁵ Giancarlo Panzica,⁶ Mauro Porta,^{2,*} Bernardo Dell'Osso,^{7-9,*} Ira David Glick^{9,*}

¹IRCCS Orthopedic Institute Galeazzi, Scientific Direction, Milan, Italy; ²IRCCS Orthopedic Institute Galeazzi, Tourette's Syndrome and Movement Disorders Centre, Milan, Italy; ³Department of Medicine and Surgery, Vita-Salute San Raffaele University, Milan, Italy; ⁴TICEA Center, Scientific Direction, Milan, Italy; ⁵Neurosurgery Department, ICCS Istituto Clinico Città Studi, Milan, Italy; ⁶Department of Neuroscience, Rita Levi Montalcini, University of Turin, Turin, Italy; ⁷University of Milan, Department of Clinical and Biomedical Sciences Luigi Sacco, ASST Fatebenefratelli-Sacco, Ospedale Sacco Polo Universitario, Milan, Italy; ⁸"Aldo Ravelli" Center for Neurotechnology and Brain Therapeutic, University of Milan, Milan, Italy; ⁹Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine, Stanford, California, USA

*These authors contributed equally to this work

Correspondence: Matteo Briguglio
IRCCS Orthopedic Institute Galeazzi,
Scientific Direction, Via Riccardo
Galeazzi, 4, Milan 20161, MI, Italy
Tel +39 338 6087042
Email matteo.briguglio@grupposandonato.it

Abstract: Neuropsychiatric disorders stem from gene-environment interaction and their development can be, at least in some cases, prevented by the adoption of healthy and protective lifestyles. Once full blown, neuropsychiatric disorders are prevalent conditions that patients live with a great burden of disability. Indeed, the determinants that increase the affliction of neuropsychiatric disorders are various, with unhealthy lifestyles providing a significant contribution in the interplay between genetic, epigenetic, and environmental factors that ultimately represent the pathophysiological basis of these impairing conditions. On one hand, the adoption of Healthy Eating education, Physical Activity programs, and Sleep hygiene promotion (HEPAS) has the potential to become one of the most suitable interventions to reduce the risk to develop neuropsychiatric disorders, while, on the other hand, its integration with pharmacological and psychological therapies seems to be essential in the overall management of neuropsychiatric disorders in order to reduce the disability and improve the quality of life of affected patients. We present an overview of the current evidence in relation to HEPAS components in the prevention and management of neuropsychiatric disorders and provide suggestions for clinical practice.

Keywords: neuropsychiatry, diet, motor activity, sleep, quality of health care

Introduction

Neurological and psychiatric disorders are among the non-communicable diseases that are associated the most with several years lived with disability, and are currently, and will likely become progressively, part of a pervasive illness affecting physical and mental fitness.¹ Indeed, these conditions continue to show a large prevalence in the general population and, in the last 10 years, a further increase in all-age years lived with disabilities has been observed for both neurological (mean increase in counts of 17.8%) and mental (mean increase in counts of 13.5%) disorders.² These conditions encompass a wide range of illnesses that affect brain anatomy and function, such as schizophrenia spectrum disorders, mood and anxiety disorders, cognitive disorders with collateral alterations of attention, mood, emotion, and memory. Diagnosis and management is often arduous because symptoms may derive from neurological, psychological, or iatrogenic causes and can easily lead to poor course and outcome. The overlap of

etiopathogenetic phenomena led to the existence of multifaceted spectra and multiple specifiers, such as the “with anxious distress” in major depressive episodes, the schizo-obsessive³ phenotype, or the tic-related obsessive-compulsive disorder,⁴ thus stressing the need for a holistic approach in neuropsychiatric disorders now more than ever. Although the current psychotropic drug- and psychotherapy-centered approaches are deemed effective for many patients, some show pharmacological refractoriness or are unable to tolerate side effects, and physical treatments have been largely implemented.⁵ Despite the fact that determinants increasing the burden of neuropsychiatric diseases are various, the behavioral factors still provide the highest contribution over metabolic and environmental/occupational risks. According to the Institute for Health Metrics and Evaluation (IHME) classification, the behavioral risks mainly comprise bad dietary habits, smoking, malnutrition, alcohol use, and low physical activity.² A consistent body of literature identifies eating patterns and physical activity as crucial determinants for physical and mental fitness, the latter being associated to a good sleep. In fact, the brain governs basic sleep/wake cycle, behavioral states and shapes cognitive functions, and sleep disturbances are often associated to a stressed body and mind. Sleep changes are often the earliest signs of several neuropsychiatric disorders, but have also been considered as state markers for mental illnesses, partly as our genetic makeup.⁶

For the purpose of the present overview, data from Google Scholar, PubMed, and Scopus databases were searched and reviewed, focusing on publications regarding diet, physical fitness, and sleeping patterns in the prevention and overall management of neuropsychiatric disorders, mainly encompassing schizophrenia spectrum disorders, mood disorders, anxiety disorders, and neurocognitive disorders. The search considered relevant studies to introduce the rationale for each section and discuss retrospective and prospective clinical trials, systematic and non-systematic reviews, meta-analyses, guidelines and expert opinions. Our ultimate aim was to deliver practical suggestions for neuropsychiatrists and clinical psychologists that can support the application of a program covering Healthy Eating education, Physical Activity planning, and Sleep hygiene (HEPAS).

Healthy Eating in Neuropsychiatry

Eating is essential to life, as well as breathing, sleeping, and evacuating. We eat for hunger, for pleasure, for boredom, and for addiction.⁷ Most people eat three meals plus snacks daily,

which is an unusual eating pattern from an evolutionary perspective,⁸ as we have been purely hunters and gatherers for thousands of years. Food had always influenced our mental abilities: the ability to harness fire and cook food allowed the brain of the *Homo erectus* to grow over 1.8 million years ago,⁹ with the progressive hypotrophy of masseter and pterygoid muscles allowing cranial development since the consumption of raw and fibrous meat was abandoned. Brain activity is constant, with activity peaks that depend on what the mind is involved in. This activity requires relentless supply of fuel that is mainly glucose, but may also be of non-carbohydrate origin, with a variety of crucial vitamins, minerals, and trace elements integrating core processes. Mechanisms through which diet influences brain functions are likely to be numerous and composite. They mainly comprise the modulation of neuronal energy metabolism and the epigenetic regulation of synaptic plasticity.¹⁰ As such, foods can affect brain function according to the content or lack of nutrients.^{11,12} Food components have a role in brain development since the early orchestration of morphogenic signaling¹³ towards late fetal and early post-natal life,¹⁴ till the modulation of adult neurogenesis. Foods routinely affect brain even if not consumed with the involvement of rewarding mechanisms.¹⁵ Substantial improvements have been achieved in the field of nutraceuticals, with antioxidant properties, immune system modulation, and neurotrophic activity¹⁶ being just some of the effects attributed to food substances that are concentrated and sold as dietary supplements.^{16–18} However, while nutrients are thoughtfully absorbed by the body, non-nutritive compounds less easily cross physiological barriers and targeted drug delivery system would be needed to properly enhance their bioavailability.¹⁹

Hunters and gatherers no longer exist, but food availability is almost excessively guaranteed with a wealth of ready-to-eat, high-calorie, tasty products, as if there was the threat of food famine. Most people have forgotten that food is medicine.²⁰ In the following paragraphs, we describe and discuss: I) the reciprocal relationship between diet and neuropsychiatric disorders, II) existing methods to assess eating habits, III) practical suggestions to promote healthy eating.

The Reciprocal Relationship Between Diet and Neuropsychiatric Disorders

The existence during early stages of life span of a bidirectional relationship between healthy diet and superior mental health has been shown by many epidemiologic

studies.²¹ Single food components are considered as significant exposure variables that concur to cause various neuropsychiatric conditions. For instance, even if neurons primarily rely on glucose to function, a high intake of sugars may be noxious and may increase the risk for depression²² and neurocognitive impairment.^{23,24} Indeed, the importance of the dietary pattern as a modifiable risk factor for mental illness gave birth to the nutritional psychiatry field.^{25,26} Unfortunately, poor dietary choices are made by patients suffering from schizophrenia,²⁷ tics, obsessions, and compulsions,^{28–31} thus further exposing patients to nutritional deficiencies that are associated with worse mental health issues.³² Moreover, unhealthy diet was reported for bipolar patients³³ and patients with depressive and anxiety disorders.³⁴ Drug therapy can easily predispose to worse physical health, being some psychotropics obesogenic in nature.³⁵ As soon as an individual adopts an unhealthy dietary pattern, his mental functions could be exposed to negative anatomical variations in critical brain areas, such as the hippocampus.^{36,37} Vascular impairments, because of glycaemic alterations, may have a role in the development of dementia³⁸ and psychiatric conditions.²² Cognitive deficits were found in individuals consuming sugar-sweetened beverages.³⁹ A new frontier in nutritional psychiatry is stemming from research targeting the modulation of the gut microbiota. In fact, diet is a direct modulator of gut microbiota, whose role has been extensively studied not only in association with neuropsychiatric diseases, but also with subclinical emotional states,⁴⁰ possibly evoked by the production of specific neurotransmitters.¹² Besides having a role in food and drug metabolism, gut microbiota composition seems to either influence or be influenced by numerous neuropsychiatric conditions, through the induction of dysbiosis and alteration of gut permeability, which can, in turn, release pro-inflammatory mediators, activate the immune system and induce a state of low-grade inflammation.⁴¹ All these mechanisms can alter brain functioning at various levels, with repercussions on mental health.

Existing Methods to Assess Eating Habits

Diet quality, quantity, meal timing, and environment are four features characterizing eating patterns. Past dietetic habits may be meticulously analyzed through dietetic history questionnaires (eg, those developed by the National Cancer Institute can be found here <https://epi.grants.cancer.gov/dhq3/>), whereas more recent eating behaviors can be derived from a seven-day food diary that can be either

paper-based or web-based.⁴² Dietetic history questionnaires are certainly more time-consuming, consisting of 135 food and beverage items and 26 dietary supplement questions. Objective evaluations of eating behaviors are quite difficult to acquire, and subjective questionnaires are widely used. Seven-day food diary is the most suitable method for an objective analysis, but also body weight changes may indeed objectively reflect all the four features of eating patterns. Dietary habits of neuropsychiatric patients might be investigated through less time-consuming tests that evaluate how similar patient's diet is to the Mediterranean dietary pattern, which is the one recognized as the healthiest. In fact, this diet has been implemented worldwide from European to American populations.⁴³ It is mainly characterized by appropriate intakes of vegetables, fruits, whole grains, dairy products, seafood, lean meats and poultry, eggs, legumes, nuts, olive oil, and alcohol. Calories from added sugars and saturated fats should be limited and sodium intake should be reduced. Healthy eating is inexpensive, and low-income individuals can afford it.⁴⁴ Higher adherence to these dietary guidelines is associated with reduced total, cardiovascular, and cancer mortality risks⁴⁵ and better general physical health.⁴⁶ Average intakes of different food groups are far from recommended amounts: about 75% of the Americans has an eating pattern that is low in vegetables, fruits, dairy, and oils, and most of subjects exceed the recommendations for added sugars, saturated fats, and sodium,⁴⁷ with important differences during the transition from adolescence to young adulthood.⁴⁸ In younger patients, the test of Serra-Majem and colleagues can be used for non-quantitatively evaluate the adherence to the Mediterranean diet.⁴⁹ The score, which was validated in healthy Spanish children and youths, consists of 16 questions with either positive (+1) or negative (–1) connotation, with the sum identifying the Mediterranean quality among three levels (ie, low, improvements needed, optimal). For adults, the literature-based adherence score to the Mediterranean diet of Sofi and colleagues might be particularly convenient.⁵⁰ The score, who was estimated from data coming from over 4 million subjects, ranges from 0 (lowest Mediterranean diet adherence) to 18 points (highest Mediterranean diet adherence), and comprises 9 quantity-based questions to be answered with the assignment of 0, 1, or 2 points each according to the higher Mediterranean connotation. Both suggested indexes can be easily used in clinical practice and they take about 5 mins each to be completed.

Practical Suggestions to Promote Healthy Eating

An adjunctive-personalized dietary advice and a nutritional counselling support, focusing on healthy eating recommendations, were found to be effective in reducing symptoms in patients with unipolar depression.⁵¹ Even small changes may be sufficient to achieve greater advantages: the addition of a specific food category, such as nuts,⁵² to an individual's eating habit may be effective in the integrated treatment of depression. Moreover, the supplementation with omega-3 fatty acids, zinc, B vitamins have been often studied in neuropsychiatric populations, with debated results.^{53,54} Targeted probiotic supplementations could be also considered an encouraging integrative approach.⁵⁵ In clinical practice, patients should be first educated to pursue an optimal quality of the diet. In some psychiatric patients, it is important to avoid restrictive and/or selective eating patterns.²⁹ Because people have different preferences for specific foods, it is important to understand whether quantity, quality, or timing is the most beneficial intervention for them. Patients should be informed that quality and timing are surely more important than quantity, at least for weight management.⁵⁶ A nutritional counseling may be more pragmatic as part of dietetic sessions to be taken with the support of written information, meal ideas, recipe examples, shopping lists, label reading instructions, and food security information.^{30,57} The tailored dietetic plan should eventually be designed to be easy to follow, sustainable, palatable, and satiating,⁵¹ with the eventual meal assistance support to convey motivational eating. The general aim should be to instruct patients to follow a balanced diet that contains suitable options for carbohydrates, proteins, lipids, vegetables, and fruits. Impulsive eating may be circumvented through the consumption of snacks in-between meals. Early identification of low baseline adherence to a specific diet, learned helplessness (ie, perceived absence of control to achieve any success) for previous attempts to lose body weight, fear or gain in body weight because of pharmacological therapy, or displeasure of body image should be investigated.²⁹ Moreover, family environment affecting food habits should be always explored, especially for younger patients.²⁸ Pathological behaviors might vitiate food habits, therefore a thoughtful assessment should be always considered.²⁹ Neuropsychiatric patients may use dietary supplements without informing their doctor, as they may consider the use of supplements not worth of note or feel uncomfortable in admitting their choice of

complementary remedies. Patients can present misperceptions about the efficacy of certain supplements, and a more scientific education should be provided for these cases.¹² Dietetic sessions should include information about conditional recommendations to avoid foods or beverages known to interfere with drug pharmacokinetic/pharmacodynamic profile.^{29,58}

Physical Activity in Neuropsychiatry

As hunters and gatherers, our ancestors trekked miles every day and had the highest activity levels⁵⁹ compared both to the present day and to our past apelike existence. In fact, our ancestors initially transitioned from a sedentary simian lifestyle to a more physically demanding hunter-gatherer one, when they started carrying out foraging tasks. This evolutionary process is believed to have promoted brain development because of the combination of aerobic activity with control of motor systems, spatial navigation, memory, executive functions including decision making and planning, and control of sensory and attentional systems.⁶⁰ "Until recently, all of us were athletes".⁶¹ It is worth of note that not only the lowest level of physical activity, but also the extensively and uninterrupted sedentary behavior are risk factors for non-communicable diseases. Keeping active improves cardiopulmonary and musculoskeletal systems, which in turn ameliorate the mechanical potential of the body. The more the physical activity, the more the branching of blood capillaries and pruning of neuronal cells.^{62,63} Physical activity affects levels of neurotransmitters, endorphins, and neurotrophic factors, such as the brain-derived neurotrophic factor, which are implicated in body and mental functioning.⁶⁴ An active lifestyle increases the antioxidant capacity and boosts the immune system (eg, myokines), thus rendering the body less vulnerable to both disease and cognitive decline. Common cellular pathways important for neurogenesis and plasticity may be synergistically promoted by physical exercise and food components.⁶⁵

Nowadays, we are provided with excessive labor-saving innovations, such as cars, elevators, and escalators, which prevent us from significantly increasing our heart rate or breaking a sweat for days. "Few jobs require physical activity and most of us have little inclination to exercise in our spare time ... Let's help each other exercise more. In fact, it's what we evolved to do".⁶¹ Exercise is medicine.⁶⁶ In the following paragraphs, we discuss and describe: I) the reciprocal relationship between physical fitness and neuropsychiatric disorders, II) existing methods

to assess physical activity levels, III) practical suggestions to promote physical activity.

The Reciprocal Relationship Between Physical Fitness and Neuropsychiatric Disorders

The less a subject moves, the more he appears to be exposed to a higher risk of anxiety and depressive disorders,^{67,68} cognitive decline and dementia.⁶⁹ Other than low physical activity, also sedentary behaviors should be reasonably avoided. Of note, different types of sedentary behaviors, such as television viewing and reading, may have a different impact on cognitive development,⁷⁰ thus suggesting that a hierarchy exists among sedentary activities, with some having to be preferred over others. In terms of physical commitment, reading and watching television are comparable activities, but most likely require different degrees of cognitive and emotional commitment as was showed by previous results comparing television viewing and regular computer use.⁷¹ Indeed, screen sedentary behavior are associated, among other routinely behaviors, with greater distress.⁷² Normally, maintaining an active outdoor lifestyle promotes mental health and mentally active subjects are those who exercise the most,⁷³ but this is not always true: professional athletes may suffer from brain disorders, with important performance affections, and these conditions gave birth, similarly to the nutritional psychiatry field, to sport psychiatry.⁷⁴ To this extent, the positive effects of an increased physical activity on mental distress cannot be always explained by physiological factors associated with ameliorated hormonal responses or endorphin production. The bi-directional relationship between a healthy brain and physical fitness is not a new concept^{75,76} and many cross-sectional studies showed that people suffering from severe mental illness, such as schizophrenia, bipolar disorder, and major depressive disorder, have very low levels of physical activity in relation with longer illness duration and drug use.⁷⁷ Not only the lowest physical activity levels, but even much time spent being sedentary are behavioral features of those subjects with severe neuropsychiatric disorders.^{78,79} Individuals who exercise the most may have a larger total brain volume, with the incremental physical activity having different effects on multiple brain regions.⁸⁰ As previously mentioned, the amelioration of hemodynamic responses may be at the basis of brain modifications upon physical exercise, extraordinarily mirroring cardiovascular

improvements and the acquisition of a general physical and psychological health.

Existing Methods to Assess Physical Activity Levels

What does “move enough” mean? Quality, quantity, timing, and environment are important specifiers of physical activity programs. The quality of physical activity comprises the intensity (ie, effort level) and type, which vary between people according to demographic and health status. Endurance, muscle-strengthening, stretching, and balance activities are the main type categories, and they are all dependent on the environment (eg, outdoor, indoor, at school, watersports, mountain sports). Quantity comprises the duration (length of training) and frequency (times per week), while the timing means the moment of the day. Objective assessment of the usual body activity, in terms of energy consumed, may derive from actigraphy, which is a non-invasive method for monitoring rest/activity cycles.⁸¹ To record physical activity, actigraphy devices (eg, single or multiple axis accelerometers) are usually worn on the wrist to record movements that can be used to estimate wavering parameters with the support of computerized algorithms. Subjective questionnaires may also be useful in order to obtain a different perceptive information, but they show more variability in properties of methodological effectiveness than objective measures,⁸² such as accelerometer/activity monitor, as the latter allows examining the motion in free-living environments.⁸³ Reliable questionnaires are available for physical activity surveillance at the population level to collect data at work, for travelling to and from places, and for recreational activities (<https://www.who.int/ncds/surveillance/steps/GPAQ/en/>), but they seem to be outdated by last generation smartphones with built-in accelerometry.⁸⁴ Diverse physical activity guidelines are available online (<https://health.gov/paguidelines/second-edition/>) with infographics that can be more suitable for the public population. To achieve at least 150 mins of moderate to vigorous physical activity a week plus muscle-strengthening activities at least 2 days a week is recommended by the physical activity guidelines for Americans,⁸⁵ with similar advices from those of the World Health Organization and specific key objectives are available for preschool-aged children, adolescents, adults and older adults. However, more than 80% of adolescents is not active enough, together with 1 in 4 adults,⁸⁶ and the overall picture could be worse for

people suffering from mental illnesses. In clinical practice, all different neuropsychiatric patient groups can be daily monitored with wrist-mounted motion sensors, which are very useful for measuring total energy expenditure,⁸⁷ thus observing the adherence to exercise programs. An actigraphy device worn on the non-dominant wrist for 2 weeks is able to give not only motor activity, but also sleep duration data in patients, with associations being reported between motor activity and mood.⁸⁸ Collected data from daily monitoring are then downloaded to a computer for display and analysis of activity/inactivity that, in turn, can be further analyzed to estimate the rest-activity circadian rhythms.⁸⁹

Practical Suggestions to Promote Physical Activity

Rather different physical exercise interventions had all positive clinical effects in patients with schizophrenia, unipolar depression, Alzheimer's disease, Huntington's disease, Parkinson's disease, and multiple sclerosis.⁹⁰ Many professionals state that the prescription of physical activity interventions should be placed on a par with drug prescription, but this implies that neuropsychiatrists "know how to prescribe, monitor, and evaluate the effectiveness of the exercise prescribed".⁹¹ However, this is not often the case and this obstacle must be overcome by the multi-disciplinary approach with the support of the exercise trainer. It is important to note that while dietary guidelines are very precise in terms of "what to eat" and "how much", physical activity guidelines are still much generalized. Various efforts and sport type combinations may have different mental health outcomes. While there are only limited ways of healthy eating (ie, the Mediterranean pattern), for physical activity it can be assumed that no matter what you do, just do something that you are allowed and enjoy. However, patients with low compliance may be more prone to poor adherence to general advices and a tailored exercise training program might be more effective than those unsupervised, as was shown in patients suffering from obsessive-compulsive disorder⁹² and depression.⁹³ Hospitalized patients are certainly more manageable, and optimal results may be achieved in a short time, as was shown after 4-month prescriptions in schizophrenic patients.⁹⁴ To the extent that people have preferences for specific exercises, it is important to understand whether different combinations of specifiers could be equally beneficial for the patients, who

should conceivably be able to choose their favorite sport, or whether it would be better to focus on certain forms of exercise to avoid. In fact, despite various benefits of sport participation may be attained, such as the opportunity to overcome challenges or to fulfill basic psychological needs, there is a dark side of sport, ranging from injuries to addictions.^{95,96} Patients with displeasure of body image or fear of gain in body weight should be carefully accompanied through mild exercise interventions, as compensatory behaviors may be present.²⁹ As stated by the guidelines, when subjects suffering from specific conditions are not able to meet the key recommendations of guidelines, they should still be engaged in regular physical activity according to their abilities, avoiding sedentary behaviors. Contrarily to the Mediterranean pattern,⁴⁴ to increase structured physical activity levels in the gym may be not affordable for high costs, but routine tips to make more movement are available (<https://www.choosemyplate.gov/physical-activity-tips>). To keep a daily active lifestyle, patients should make tricks to increase physical activity at home, at work, at school, in the community (eg, park the car away from the workplace, get off public transport a few stations before). Generally, little structured physical activity is much better than too much and unfocused, and sports with teammates are always preferable to individual sports.

Sleep in Neuropsychiatry

Sleeping is a neurobiological state that occupies about 30–35% of our entire lifespan (7–8 hrs/night), being an essential behavioral factor for human life that is affected by environment, technology, and our 24/7 society.⁹⁷ Post-industrialized sleep hygiene is different from sleep of hominin ancestors, primarily attributed to changed sleep environment (ie, sleep site) that includes photoperiod, thermal stress, noise, sociality, and familiarity of surroundings.⁹⁸ However, sleep states are conserved across diverse animal species, possibly because of their brain-stem-dependence (highly conserved among vertebrates), in turn suggesting that sleep drives a common benefit to animal survival, which seems to be also related to the clearance of brain metabolites.⁹⁹ As we mentioned earlier, brain activity is constant and it primarily depends on the level of arousal, with a totally different pattern around day and night cycle. During the night, sleep cycles between two distinct states: the Rapid Eye Movement (REM) sleep, which occurs with vivid dreams, and the non-REM sleep, which occurs after sleep onset, both stages being

distinguished through electroencephalogram or electromyogram. An imbalance between the two sleep states represents an early symptom of various neuropsychiatric disorders, suggesting that both sleep states have important roles.¹⁰⁰

We mention that healthy eating and physical activity are worth promoting in patients affected by neuropsychiatric conditions, but we argue sleep hygiene is the third player of this triad to be promoted in terms of good quality and quantity. The compromising neurobehavioral performance resulting from poor sleep might indeed induce neuropsychiatric symptoms in healthy subjects and worsen the condition of affected subjects, therefore deeming necessary to consider also this aspect in clinical practice. In the following paragraphs, we discuss and describe: I) the reciprocal relationship between sleep and neuropsychiatric disorders, II) existing methods to assess sleep, III) practical suggestions to promote sleep hygiene.

The Reciprocal Relationship Between Sleep and Neuropsychiatric Disorders

Sleep acts as a mediator of cognition, mood, and emotional memory¹⁰¹ and, therefore, poor sleep hygiene is associated with worse mental health in both adolescents and adults. In healthy youths, short weekday sleep duration was associated with increased odds of mood, anxiety, substance use, and behavioral disorders.¹⁰² Both poor sleep quantity and quality (ie, insomnia) are associated with worse mental health. For instance, short sleep durations are known to be a significant predictor of developing depression during adulthood¹⁰³ and subjects with insomnia are almost 10 or 17 times more likely to develop a depressive disorder or an anxiety disorder than good sleepers.¹⁰⁴ Sleep disorders have been intertwined with concomitant neuropsychiatric conditions¹⁰⁵ and different sleep structures can differentiate the clinical phenotypes, for instance between bipolar disorder and attention-deficit hyperactivity disorder.¹⁰⁶ Indeed, laboratory-based studies have demonstrated that sleep abnormalities are commonly present in affective disorders since years.^{107,108} However, sleep disturbances still represent a growing public health concern, affecting youths and older adults suffering from neuropsychiatric diseases. About 88% of children with anxiety disorders exhibits sleep disturbances¹⁰⁹ and main complaints in adults suffering from Alzheimer's disease include fragmentation of nocturnal sleep, prolonged awakenings, REM sleep abnormalities, and daytime sleepiness

with frequent napping.¹¹⁰ Sleep may be disturbed in some patients with obsessive thoughts that prevent them from falling asleep.²⁹ Sleep disturbances are also present in patients with bipolar disorder¹¹¹ and even non-treated schizophrenic patients,¹¹² clearly demonstrating that sleep is directly affected by the disease rather than drugs themselves. Interestingly, the clinical response to a specific drug therapy may be predicted by the cellular circadian rhythms in some patients.¹¹³ Indeed, circadian rhythm disturbances may be one of the key etiological factors for neuropsychiatric disease onset, as they are frequently present in children diagnosed with attentional or hyperactive symptoms¹¹⁴ and in older adults suffering from dementing disorders.¹¹⁵

Existing Methods to Assess Sleep

Sleep quality, quantity, timing (fractal or condensed), and environment are four features that characterize sleep hygiene. As happens for eating patterns, quality appears to be the most important, because of its comprehensive annexation with efficiency (ie, time in bed spent sleeping), latency to fall asleep, and time in bed spent awake at night (we assume to have diurnal behaviors) after first falling asleep. Sleep behavior can be studied through several objective methods, such as polysomnography and actigraphy, or subjective methods, such as the more practical sleep diaries. Polysomnography refers to the continuous monitoring of multiple neurophysiological and cardiorespiratory variables over the night course¹¹⁶ and specifically provides information about physiological changes occurring in relation to sleep stages and wakefulness.¹¹⁷ The reference for the evaluation (<https://aasm.org/clinical-resources/scoring-manual/>) comprehensively provides rules for scoring sleep stages, arousals, respiratory events during sleep, movements during sleep and cardiac events, but it may be of limited use for clinical routine. Of note, existing recommendations for a good sleep hygiene focus on the sole quantity factor. The hours of sleep per night should be at least eight and seven for healthy adolescents¹¹⁸ and adults,¹¹⁹ respectively. Failing to meet these recommendations is associated with poorer physical health in youths¹²⁰ and adults.¹²¹ Overall, almost one third of adults in the US sleep less than 7 hrs in a 24 hr period.¹²² Furthermore, sleep quality seems to be far from being optimal with insomnia being one of the most prevalent health problems related to sleep. Insomnia is a chronic condition with difficulties in initiating and maintaining sleep that occurs in approximately 9–15% of the world population with daytime

consequences.^{123,124} Dietary supplements to alleviate insomnia symptoms are used in about 15% of cases,⁷² potentially exposing to drug–food interactions.^{58,125} Despite not being the gold standard method for sleep monitoring, actigraphy can certainly represent a useful alternative and many scientific studies have been conducted with this objective method in different settings.^{126,127} Actigraphy devices worn on the wrist record movements that can be used to estimate total sleep time and wakes after sleep onset.¹²⁸ Since decades, the American Academy of Sleep Medicine highlighted actigraphy as a valid and cost-effective method for diagnosing insomnia, circadian rhythm disorders, or excessive sleepiness.¹²⁹ Other practical tools are sleep diaries and questionnaires, which quantitatively summarize the individual's perception of sleep, and can easily be used to monitor the behavioral treatment of sleep disorders.¹³⁰ Sleep questionnaires are filled in once, while sleep diaries are filled in over a period of time, thus underscoring the greater amount of information recorded by the latter. Similar to dietary or physical activity questionnaires, sleep questionnaires are influenced by different sources of bias and inaccuracy, but their subjectivity does not necessarily provide inaccurate results. Since many sleep questionnaires, scales, and diaries have been validated and proposed¹³⁰ and since their primary outcome can be extremely different (eg, sleep quality or daytime sleepiness), the selection of a questionnaire should be based on the purpose of each specific study or clinical question. A recent study by Ibanez and colleagues⁸¹ created and provided a public repository where all sleep diaries and questionnaires can be downloaded (<http://users.dsic.upv.es/~jsilva/Sleep/>).

Practical Suggestions to Promote Sleep Hygiene

A cognitive-behavioral sleep intervention was able to ameliorate self-reported indices of sleep, daytime sleepiness, anxiety, and depression in adolescents with higher levels of anxiety and depressive symptoms.¹³¹ The treatment of sleep-wake alterations in older adults with dementing disorders may provide immediate benefits on neuropsychiatric symptoms.¹³² Light, as the main environmental modulator of the biological clock, is able to resynchronize the circadian system and bright-light therapy is currently proposed for the treatment of seasonal affective disorder, and in cases of non-seasonal depression, and bipolar depression.¹³³ In clinical practice,

actigraphy represents the more practical method to detect activity-rest circadian rhythms disorders in patient's natural sleep environment.¹³⁴ Nevertheless, sleep diaries and questionnaires should be always used to complement the objective evaluations. As mentioned for the dietetic sessions, sleep hygiene education may be more concrete with the support of written information. Generally, behaviors that augment physiological or mental arousal, or which delay the circadian phase, should be avoided. For instance, the consumption of methylxanthine-containing beverages, such as coffee, tea, and guarana should be avoided close to bedtime. Also, smoking should be avoided because of its insomnia-like sleep impairments,¹³⁵ but also alcohol.²⁹ Indeed, sleep may be indirectly favored by the abovementioned dietary and physical activity interventions, but patients may take prescribed or over-the-counter sleeping aids, such as melatonin.¹³⁶ Neuropsychiatric patients should be educated to ensure that their sleep environment is relaxing (eg, no light or noise, comfortable bed), by also limiting the use of mobile phones and television during bedtime. Concomitantly, patients should keep an active lifestyle (regular moderate-intensity aerobic exercise),¹³⁷ avoid heavy food close to bedtime,¹³⁸ avoid sugar-sweetened or energy beverages,^{139–141} and possibly follow a tailored sleep plan or even use actionable resources, such as apps that promote sleep self-monitoring.¹⁴²

Conclusion

The medical-surgical world is increasingly oriented towards drug- or surgeon-centered treatments. Obesity is treated with anti-obesity medications or bariatric surgery,^{143,144} insomnia with transcranial magnetic stimulation,¹⁴⁵ and treatment-resistant conditions with neurosurgical implants.¹⁴⁶ It seems that multiple benefits deriving from healthy diet, physical activity, and restful sleep have been progressively forgotten. The impending global pandemics of obesity and sleep disturbances are not effectively controlled by lifestyle interventions because the integration in clinical practice has never been systematic. Neuropsychiatric patients were often reported to have unhealthy dietary habits,^{27,34,147,148} sedentary behaviors,^{77–79} and poor sleep hygiene.^{109–112} Even if some neuropsychiatric conditions can directly or indirectly affect eating behaviors,²⁹ in terms of direction of causality, a poor diet has remarkably been shown to precede the onset of mental illnesses,¹⁴⁹ with similar time dependence for both sedentary lifestyles and poor sleep.^{150,151} Our suggestions, proposed in [Table 1](#), may be applied to the general

Table 1 Considerations for Clinical Practice Regarding Single Determinants of Healthy Eating, Physical Activity, and Sleep Hygiene (HEPAS) in Patients at Risk for or with Neuropsychiatric Disorders

<p>Healthy eating in neuropsychiatry practice</p> <ul style="list-style-type: none"> • Do not skip breakfast • Avoid sugar-sweetened beverages • Eat complex carbohydrates (eg, whole grain pasta, rice, or bread) more than once a day • Eat vegetables and fruits more than once a day, following seasonality • Rotate second courses with meat, fish, legumes, dairy products, or eggs • Prefer vegetable oils (eg, olive oil) other than animal fats, such as butter or lard • Avoid fast-food (eg, hamburger) restaurants, commercially baked goods, pastries, sweets • Avoid unnecessary dietary supplements, which may cause drug-nutraceuticals interactions • Do not eat excessively • Try to eat always at the same hours • Share meals with family members or friends
<p>Physical activity in neuropsychiatry practice</p> <ul style="list-style-type: none"> • Keep an active lifestyle to achieve over 150 mins of moderate-intensity aerobic exercise per week • Adopts tricks to increase physical activity at home, at work, at school, in the community (eg, park the car away from the workplace, get off public transport a few stations before) • Do sports that you are allowed to do and that you enjoy • Little structured physical activity is much better than too much and unfocused • Do physical activities not close to meals or bedtime • Move with family members or friends
<p>Sleep hygiene in neuropsychiatry practice</p> <ul style="list-style-type: none"> • Sleep at least 7 hrs per night, avoiding unnecessary daytime naps • Try to go to bed and wake up always at the same hours • Limit the use of mobile phones and television during bedtime • Make sure that the sleep environment is relaxing (eg, no light or noise, comfortable bed) • Do not sleep excessively: a good nap is better than a bad sleep • Avoid heavy food or strenuous physical activity close to bedtime • Avoid methylxanthines (eg, coffee, tea, guarana, energy drinks), smoking, or alcohol

neuropsychiatric population, with no regard for age, gender, or ethnicity. Public and private clinics, university hospitals, and research facilities are encouraged to integrate HEPAS, in order to pursue better course and outcome compared to related standard of care.

Disadvantages, Barriers, Advantages

In Neuropsychiatry, routine screening of eating behaviors, physical activity levels, and sleep patterns are not always

accurate, mostly due to packed schedules or growing case-loads that prevent proper multidisciplinary interactions between neuropsychiatrists, nutritionists, and exercise trainers. HEPAS applicability may also be limited according to patient's severity/stage of disease and resource availability (eg, financial burden, lack of specialized personnel). Moreover, all three factors are quite onerous to monitor (weak point = low compliance) and patients are not often informed enough, hyperinformed (which may be probably worse), uneducated, and socially unengaged.^{152,153} However, HEPAS epitomizes the novel approach that accounts for modifiable factors not only to ameliorate the grueling years lived with disability after diagnosis through tertiary preventive interventions, but also to avoid complications of clinical spectrum or to reduce disease onset through primary preventive interventions. HEPAS may certainly account for other non-communicable disease associated with the longest years lived with disability, such as musculoskeletal disorders (ie, osteosarcopenia in older adults with mild cognitive impairment), diabetes, kidney and cardiovascular diseases that are often comorbid with neuropsychiatric disorders.^{154,155} Single HEPAS components were reported to provide various advantages also in neuropsychiatric populations, but no study ever investigated all of the three components.

Past Evidences

HEPAS determinants are exceedingly intertwined, so that one cannot be dissociated from another. The combination of healthy eating and right amount of physical activity was observed to have multiplicative effects on mortality risk reduction.¹⁵⁶ The worse a subject eat the less active he is, and that was confirmed for both children and adults.^{157,158} Moreover, youths who sleep little may be more prone to fast food consumption and vegetable or fruit avoidance,¹⁴⁰ with late sleep timing being associated with increased consumption of energy drinks, sugar-sweetened beverages, and breakfast skipping.¹³⁹ These associations may be due to changes in appetite regulatory hormones that subsequently contribute to overeating and obesity.^{159,160} Conversely, eating habits can influence sleep through gut microbiota modulation.¹⁶¹ Staying active is clearly better because it ameliorates sleep quality¹⁶² and mood¹⁶³ not only in youths, but also in adults and elderly in turn providing a more resting sleep.¹⁶⁴ Regular physical activity has also positive effects on sleep quantity,¹⁶⁵ and the amelioration of sleep habits is in turn associated with a general risk reduction for obesity, heart diseases, and

diabetes,¹⁶⁶ which are conditions often being counted among the long-term metabolic side effects of neuropsychiatric drugs. Previously, some authors already acknowledged this concept of reciprocity among apparently disconnected domains, and advocated interventions targeting multiple factors simultaneously rather than focusing on single components. Similarly to HEPAS, a past multidomain lifestyle-based intervention provided ample evidence about the importance of coupling nutritional advices, exercise, and mental training for cognitive decline prevention.¹⁶⁷ In the same field, other trials targeted disease onset reduction through support in chronic disease management, smoking cessation, and health coaching.¹⁶⁸

Future Directions

We support the integration of HEPAS as central determinant in the prevention and multimodal approach of neuropsychiatric disorders, thus ultimately encouraging multidisciplinary interactions between specialists and researchers. Conceivably, high quality and adequately powered clinical trials should investigate HEPAS into diverse settings and disease populations in order to take full advantage of these behavioral interventions. In particular, there is the need of prospective experimental studies with an appropriate research methodology to legitimately support the beneficial effects of dietary,¹⁶⁹ exercise,¹⁷⁰ and sleep programs as primary or secondary prevention initiatives. Both youths and adults should be included in interventional studies, being the



Healthy Eating, Physical Activity, and Sleep hygiene (HEPAS)

Steering group:
Matteo Briguglio, Mauro Porta, Bernardo Dell'Osso, and Ira David Glick.

The winning triad for sustaining physical and mental health in patients at risk for or with neuropsychiatric disorders

Adopt a healthy and balanced diet

- Diet quality: consume a proper food variety
- Diet quantity: do not eat excessively
- Food timing: try to eat always at same hours
- Food environment: share meals with family/friends

Get enough resting sleep

- Sleep quality: a good nap is better than a bad sleep
- Sleep quantity: sleep enough, but not too much
- Sleep timing: try to maintain bedtime at same hours
- Sleep environment: prep bedroom to aid sleep

Keep in touch with doctors

- Undergo periodic health screenings
- Maintain a high adherence to the pharmacological therapy
- Avoid unnecessary dietary supplements
- Feedback your doctor about doubts and concerns

Stay daily active

- Physical activity quality: do what you are allowed to do
- Physical activity quantity: try to move every day
- Physical activity timing: move not close to meals or bedtime
- Physical activity environment: move with friends/family

We support the integration of HEPAS as central determinant in the prevention and multimodal approach of neuropsychiatric disorders, thus ultimately encouraging multidisciplinary interactions between specialists and researchers. Conceivably, clinical trials should investigate HEPAS into diverse settings and disease populations in order to take full advantage of these behavioral interventions. Both youths and adults should be included in interventional studies. Real-world approaches to promote healthy habits, enhance physical activity, and increase sleep quality should be investigated, being social engagement the common denominator.

Figure 1 Scholarly infographic depicting the Healthy Eating, Physical Activity, and Sleep hygiene (HEPAS) in patients at risk for or with neuropsychiatric disorders.

research on adolescent populations even more important because of the negative trend towards adulthood for healthy eating,¹⁷¹ physical activity,¹⁷² and sleep.¹⁷³ Real-world approaches to promote healthy habits, increase sleep time, and enhance physical activity should be investigated, being social engagement the common denominator. Patients should be ultimately confident, motivated, and enabled to sustain long-term health outcomes. Infographic of [Figure 1](#) comprehensively summarizes our considerations for clinical practice, also comprising advices on a proper therapeutic alliance. Importantly, caregivers and family members should always be involved in this multimodal approach to practically and psychologically support the individual. If necessary, psychotherapists and life coaches may be involved to enhance compliance and community-based engagement.¹⁵² We know all positive effects of abovementioned HEPAS interventions, but for instance, how does an individual eat better, sleep better, and do exercise? Since each component can provide various advantages per se, the possibility of combined use of all three interventions unlocks numerous potential avenues, facilitating a comprehensive management of neuropsychiatric disorders in affected patients.

Author Contributions

All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

Professor Ira Glick reports research support from Alkermes, speaker's bureau from Sunovion, consultant from Neurocrine, equity from Johnson & Johnson, outside the submitted work. This study was part of the Italian project "Ricerca Corrente del Ministero Della Salute". The authors report no other conflicts of interest in this work.

References

- Vigo D, Thornicroft G, Atun R. Estimating the true global burden of mental illness. *Lancet Psychiatry*. 2016;3(2):171–178. doi:10.1016/S2215-0366(15)00505-2
- Disease GBD, Injury I, Prevalence C. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet*. 2018;392(10159):1789–1858.
- Poyurovsky M, Zohar J, Glick I, et al. Obsessive-compulsive symptoms in schizophrenia: implications for future psychiatric classifications. *Compr Psychiatry*. 2012;53(5):480–483. doi:10.1016/j.comppsy.2011.08.009
- Dell'Osso B, Marazziti D, Albert U, et al. Parsing the phenotype of obsessive-compulsive tic disorder (OCTD): a multidisciplinary consensus. *Int J Psychiatry Clin Pract*. 2017;21:1–4.
- Malhi GS, Loo C, Cahill CM, Lagopoulos J, Mitchell P, Sachdev P. "Getting physical": the management of neuropsychiatric disorders using novel physical treatments. *Neuropsychiatr Dis Treat*. 2006;2(2):165–179. doi:10.2147/ndt.2006.2.issue-2
- Rusterholz T, Hamann C, Markovic A, Schmidt SJ, Achermann P, Tarokh L. Nature and nurture: brain region-specific inheritance of sleep neurophysiology in adolescence. *J Neurosci*. 2018;38(43):9275–9285. doi:10.1523/JNEUROSCI.0945-18.2018
- Ruddock HK, Dickson JM, Field M, Hardman CA. Eating to live or living to eat? Exploring the causal attributions of self-perceived food addiction. *Appetite*. 2015;95:262–268. doi:10.1016/j.appet.2015.07.018
- Mattson MP, Allison DB, Fontana L, et al. Meal frequency and timing in health and disease. *Proc Natl Acad Sci U S A*. 2014;111(47):16647–16653. doi:10.1073/pnas.1413965111
- Bradt S. Invention of cooking drove evolution of the human species, new book argues. 2009. Available from: <https://news.harvard.edu/gazette/story/2009/06/invention-of-cooking-drove-evolution-of-the-human-species-new-book-argues/>. Accessed December 12, 2019.
- Gomez-Pinilla F, Tyagi E. Diet and cognition: interplay between cell metabolism and neuronal plasticity. *Curr Opin Clin Nutr Metab Care*. 2013;16(6):726–733. doi:10.1097/MCO.0b013e328365aae3
- Harrison NL, Skelly MJ, Grosserode EK, et al. Effects of acute alcohol on excitability in the CNS. *Neuropharmacology*. 2017;122:36–45. doi:10.1016/j.neuropharm.2017.04.007
- Briguglio M, Dell'Osso B, Panzica G, et al. Dietary neurotransmitters: a narrative review on current knowledge. *Nutrients*. 2018;10(5):591. doi:10.3390/nu10050591
- Knobloch M, Jessberger S. Metabolism and neurogenesis. *Curr Opin Neurobiol*. 2017;42:45–52. doi:10.1016/j.conb.2016.11.006
- Cusick SE, Georgieff MK. The role of nutrition in brain development: the golden opportunity of the "first 1000 days". *J Pediatr*. 2016;175:16–21. doi:10.1016/j.jpeds.2016.05.013
- Spence C, Okajima K, Cheok AD, Petit O, Michel C. Eating with our eyes: from visual hunger to digital satiation. *Brain Cogn*. 2016;110:53–63. doi:10.1016/j.bandc.2015.08.006
- Carito V, Ceccanti M, Tarani L, Ferraguti G, Chaldakov GN, Fiore M. Neurotrophins' modulation by olive polyphenols. *Curr Med Chem*. 2016;23(28):3189–3197. doi:10.2174/0929867323666160627104022
- Neshatdoust S, Saunders C, Castle SM, et al. High-flavonoid intake induces cognitive improvements linked to changes in serum brain-derived neurotrophic factor: two randomised, controlled trials. *Nutr Healthy Aging*. 2016;4(1):81–93. doi:10.3233/NHA-1615
- Gomez-Pinilla F. Brain foods: the effects of nutrients on brain function. *Nat Rev Neurosci*. 2008;9(7):568–578. doi:10.1038/nrn2421
- Enteshari Najafabadi R, Kazempour N, Esmaili A, Beheshti S, Nazifi S. Using superparamagnetic iron oxide nanoparticles to enhance bioavailability of quercetin in the intact rat brain. *BMC Pharmacol Toxicol*. 2018;19(1):59. doi:10.1186/s40360-018-0249-7
- Mozaffarian D, Mande J, Micha R. Food is medicine—the promise and challenges of integrating food and nutrition into health care. *JAMA Intern Med*. 2019;179(6):793–795. doi:10.1001/jamainternmed.2019.0184
- O'Neil A, Quirk SE, Housden S, et al. Relationship between diet and mental health in children and adolescents: a systematic review. *Am J Public Health*. 2014;104(10):e31–e42. doi:10.2105/AJPH.2014.302110
- Salari-Moghaddam A, Saneei P, Larijani B, Esmailzadeh A. Glycemic index, glycemic load, and depression: a systematic review and meta-analysis. *Eur J Clin Nutr*. 2019;73(3):356–365. doi:10.1038/s41430-018-0258-z

23. Pistollato F, Iglesias RC, Ruiz R, et al. Nutritional patterns associated with the maintenance of neurocognitive functions and the risk of dementia and alzheimer's disease: a focus on human studies. *Pharmacol Res.* 2018;131:32–43. doi:10.1016/j.phrs.2018.03.012
24. Psaltopoulou T, Sergentanis TN, Panagiotakos DB, Sergentanis IN, Kostis R, Scarmeas N. Mediterranean diet, stroke, cognitive impairment, and depression: a meta-analysis. *Ann Neurol.* 2013;74(4):580–591. doi:10.1002/ana.v74.4
25. Sarris J, Logan AC, Akbaraly TN, et al. Nutritional medicine as mainstream in psychiatry. *Lancet Psychiatry.* 2015;2(3):271–274. doi:10.1016/S2215-0366(14)00051-0
26. Marx W, Moseley G, Berk M, Jacka F. Nutritional psychiatry: the present state of the evidence. *Proc Nutr Soc.* 2017;76(4):427–436. doi:10.1017/S0029665117002026
27. McCreadie RG; Scottish Schizophrenia Lifestyle G. Diet, smoking and cardiovascular risk in people with schizophrenia: descriptive study. *Br J Psychiatry.* 2003;183:534–539. doi:10.1192/bjp.183.6.534
28. Briguglio M, Zanaboni Dina C, Servello D, Porta M Tourette syndrome and nutritional implications. 9^o meeting of european society for the study of tourette syndrome. COST International Conference for Tourette Syndrome; 2016; Warsaw.
29. Briguglio M, Dell'Osso B, Galentino R, Zanaboni Dina C, Banfi G, Porta M. Tics and obsessive-compulsive disorder in relation to diet: two case reports. *Encephale.* 2018 Nov ;44(5):479–481. doi:10.1016/j.encep.2017.06.004.
30. Briguglio M, Dell'Osso B, Galentino R, Banfi G, Porta M. Higher adherence to the mediterranean diet is associated with reduced tics and obsessive-compulsive symptoms: a series of nine boys with obsessive-compulsive tic disorder. *Nutr Clin Metab.* 2019;33(3):227–230. doi:10.1016/j.nupar.2019.04.004
31. Vitale JA, Briguglio M, Galentino R, et al. Exploring circannual rhythms and chronotype effect in patients with Obsessive-Compulsive Tic Disorder (OCTD): a pilot study. *J Affect Disord.* 2020 Feb 1;262:286–292. doi:10.1016/j.jad.2019.11.040.
32. Jacka FN, Pasco JA, Mykletun A, et al. Association of Western and traditional diets with depression and anxiety in women. *Am J Psychiatry.* 2010;167(3):305–311. doi:10.1176/appi.ajp.2009.09060881
33. Lojko D, Stelmach-Mardas M, Suwalska A. Diet quality and eating patterns in euthymic bipolar patients. *Eur Rev Med Pharmacol Sci.* 2019;23(3):1221–1238. doi:10.26355/eurrev_201902_17016
34. Gibson-Smith D, Bot M, Brouwer IA, Visser M, Penninx B. Diet quality in persons with and without depressive and anxiety disorders. *J Psychiatr Res.* 2018;106:1–7. doi:10.1016/j.jpsychires.2018.09.006
35. Domecq JP, Prutsky G, Leppin A, et al. Clinical review: drugs commonly associated with weight change: a systematic review and meta-analysis. *J Clin Endocrinol Metab.* 2015;100(2):363–370. doi:10.1210/jc.2014-3421
36. Akbaraly T, Sexton C, Zsoldos E, et al. Association of long-term diet quality with hippocampal volume: longitudinal cohort study. *Am J Med.* 2018;131(11):1372–1381 e1374. doi:10.1016/j.amjmed.2018.07.001
37. Jacka FN, Cherbuin N, Anstey KJ, Sachdev P, Butterworth P. Western diet is associated with a smaller hippocampus: a longitudinal investigation. *BMC Med.* 2015;13:215. doi:10.1186/s12916-015-0461-x
38. Pardeshi R, Bolshette N, Gadhav K, et al. Insulin signaling: an opportunistic target to minimize the risk of alzheimer's disease. *Psychoneuroendocrinology.* 2017;83:159–171. doi:10.1016/j.psyneuen.2017.05.004
39. Munoz-Garcia MI, Martinez-Gonzalez MA, Martin-Moreno JM, et al. Sugar-sweetened and artificially-sweetened beverages and changes in cognitive function in the SUN project. *Nutr Neurosci.* 2019. 1–9. doi:10.1080/1028415X.2019.1580919
40. Taylor AM, Thompson SV, Edwards CG, Musaad SMA, Khan NA, Holscher HD. Associations among diet, the gastrointestinal microbiota, and negative emotional states in adults. *Nutr Neurosci.* 2019;1–10. doi:10.1080/1028415X.2019.1582578
41. Valles-Colomer M, Falony G, Darzi Y, et al. The neuroactive potential of the human gut microbiota in quality of life and depression. *Nat Microbiol.* 2019;4:623–632. doi:10.1038/s41564-018-0337-x
42. Fuller NR, Fong M, Gerofi J, et al. Comparison of an electronic versus traditional food diary for assessing dietary intake-A validation study. *Obes Res Clin Pract.* 2017;11(6):647–654. doi:10.1016/j.orcp.2017.04.001
43. DeSalvo KB, Olson R, Casavale KO. Dietary guidelines for Americans. *JAMA.* 2016;315(5):457–458. doi:10.1001/jama.2015.18396
44. Jetter KM, Adkins J, Cortez S, Hopper GK Jr, Shively V, Styne DM. Yes we can: eating healthy on a limited budget. *J Nutr Educ Behav.* 2019;51(3):268–276. doi:10.1016/j.jneb.2018.12.002
45. Fresan U, Sabate J, Martinez-Gonzalez MA, Segovia-Siapco G, de la Fuente-arriaga C, Bes-Rastrollo M. Adherence to the 2015 Dietary guidelines for Americans and mortality risk in a mediterranean cohort: the SUN project. *Prev Med.* 2019;118:317–324. doi:10.1016/j.ypmed.2018.11.015
46. Jessri M, Lou WY, L'Abbe MR. The 2015 dietary guidelines for Americans is associated with a more nutrient-dense diet and a lower risk of obesity. *Am J Clin Nutr.* 2016;104(5):1378–1392. doi:10.3945/ajcn.116.132647
47. US Department of Health and Human Services and US Department of Agriculture. Shifts needed to align with healthy eating patterns - a closer look at current intakes and recommended shifts. 2015. Available from: <https://health.gov/dietaryguidelines/2015/guidelines/chapter-2/a-closer-look-at-current-intakes-and-recommended-shifts/#a-closer-look-at-current-intakes-and-recommended-shifts>, <https://health.gov/dietaryguidelines/2015/guidelines/chapter-2/current-eating-patterns-in-the-united-states/>.
48. Christoph MJ, Larson NI, Winkler MR, Wall MM, Neumark-Sztainer D. Longitudinal trajectories and prevalence of meeting dietary guidelines during the transition from adolescence to young adulthood. *Am J Clin Nutr.* 2019;109(3):656–664. doi:10.1093/ajcn/nqy333
49. Serra-Majem L, Ribas L, Ngo J, et al. Food, youth and the mediterranean diet in Spain. Development of KIDMED, mediterranean diet quality index in children and adolescents. *Public Health Nutr.* 2004;7(7):931–935. doi:10.1079/PHN2004556
50. Sofi F, Macchi C, Abbate R, Gensini GF, Casini A. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutr.* 2014;17(12):2769–2782. doi:10.1017/S1368980013003169
51. Jacka FN, O'Neil A, Opie R, et al. A randomised controlled trial of dietary improvement for adults with major depression (the 'SMILES' trial). *BMC Med.* 2017;15(1):23. doi:10.1186/s12916-017-0791-y
52. Sanchez-Villegas A, Martinez-Gonzalez MA, Estruch R, et al. Mediterranean dietary pattern and depression: the PREDIMED randomized trial. *BMC Med.* 2013;11:208. doi:10.1186/1741-7015-11-208
53. Deacon G, Kettle C, Hayes D, Dennis C, Tucci J. Omega 3 polyunsaturated fatty acids and the treatment of depression. *Crit Rev Food Sci Nutr.* 2017;57(1):212–223. doi:10.1080/10408398.2013.876959
54. Yatham LN, Kennedy SH, Parikh SV, et al. Canadian Network for Mood and Anxiety Treatments (CANMAT) and International Society for Bipolar Disorders (ISBD) 2018 guidelines for the management of patients with bipolar disorder. *Bipolar Disord.* 2018;20(2):97–170.
55. Slykerman RF, Hood F, Wickens K, et al. Effect of lactobacillus rhamnosus HN001 in pregnancy on postpartum symptoms of depression and anxiety: a randomised double-blind placebo-controlled trial. *EBioMedicine.* 2017;24:159–165. doi:10.1016/j.ebiom.2017.09.013

56. Gardner CD, Trepanowski JF, Del Gobbo LC, et al. Effect of low-fat vs low-carbohydrate diet on 12-month weight loss in overweight adults and the association with genotype pattern or insulin secretion: the DIETFITS randomized clinical trial. *JAMA*. 2018;319(7):667–679. doi:10.1001/jama.2018.0245
57. O’Neil A, Berk M, Itsiopoulos C, et al. A randomised, controlled trial of a dietary intervention for adults with major depression (the “SMILES” trial): study protocol. *BMC Psychiatry*. 2013;13:114. doi:10.1186/1471-244X-13-114
58. Briguglio M, Hrelia S, Malaguti M, et al. Food bioactive compounds and their interference in drug pharmacokinetic/pharmacodynamic profiles. *Pharmaceutics*. 2018;10(4):277. doi:10.3390/pharmaceutics10040277
59. Pontzer H, Wood BM, Raichlen DA. Hunter-gatherers as models in public health. *Obes Rev*. 2018;19(Suppl 1):24–35. doi:10.1111/obr.v19.S1
60. Raichlen DA, Alexander GE. Adaptive capacity: an evolutionary neuroscience model linking exercise, cognition, and brain health. *Trends Neurosci*. 2017;40(7):408–421. doi:10.1016/j.tins.2017.05.001
61. Lieberman D, Baggish A. Exercise: it’s what we evolved to do. 2013. Available from: <https://edition.cnn.com/2013/11/01/health/evolution-exercise/index.html>. Accessed December 12, 2019.
62. Vecchio F, Babiloni C, Lizio R, et al. Resting state cortical EEG rhythms in alzheimer’s disease: toward EEG markers for clinical applications: a review. *Suppl Clin Neurophysiol*. 2013;62:223–236.
63. Hillman CH, Buck SM, Themanson JR, Pontifex MB, Castelli DM. Aerobic fitness and cognitive development: event-related brain potential and task performance indices of executive control in preadolescent children. *Dev Psychol*. 2009;45(1):114–129. doi:10.1037/a0014437
64. Lin TW, Kuo YM. Exercise benefits brain function: the monoamine connection. *Brain Sci*. 2013;3(1):39–53. doi:10.3390/brainsci3010039
65. van Praag H. Exercise and the brain: something to chew on. *Trends Neurosci*. 2009;32(5):283–290. doi:10.1016/j.tins.2008.12.007
66. American College of Sports Medicine (ACSM). Exercise is medicine. Exercise is medicine[®]: a global health initiative. 2019. Available from: <https://www.exerciseismedicine.org/>. Accessed December 12, 2019.
67. Schuch FB, Stubbs B, Meyer J, et al. Physical activity protects from incident anxiety: a meta-analysis of prospective cohort studies. *Depress Anxiety*. 2019. doi:10.1002/da.22915
68. Schuch FB, Vancampfort D, Firth J, et al. Physical activity and incident depression: a meta-analysis of prospective cohort studies. *Am J Psychiatry*. 2018;175(7):631–648. doi:10.1176/appi.ajp.2018.17111194
69. Blondell SJ, Hammersley-Mather R, Veerman JL. Does physical activity prevent cognitive decline and dementia?: A systematic review and meta-analysis of longitudinal studies. *BMC Public Health*. 2014;14:510. doi:10.1186/1471-2458-14-510
70. Carson V, Kuzik N, Hunter S, et al. Systematic review of sedentary behavior and cognitive development in early childhood. *Prev Med*. 2015;78:115–122. doi:10.1016/j.ypmed.2015.07.016
71. Kesse-Guyot E, Charreire H, Andreeva VA, et al. Cross-sectional and longitudinal associations of different sedentary behaviors with cognitive performance in older adults. *PLoS One*. 2012;7(10):e47831. doi:10.1371/journal.pone.0047831
72. Morin CM, LeBlanc M, Daley M, Gregoire JP, Merette C. Epidemiology of insomnia: prevalence, self-help treatments, consultations, and determinants of help-seeking behaviors. *Sleep Med*. 2006;7(2):123–130. doi:10.1016/j.sleep.2005.08.008
73. Elbe AM, Lyhne SN, Madsen EE, Krstrup P. Is regular physical activity a key to mental health? Commentary on “association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: A cross-sectional study”, by Chekroud et al., published in *lancet psychiatry*. *J Sport Health Sci*. 2019;8(1):6–7. doi:10.1016/j.jshs.2018.11.005
74. Glick ID, Castaldelli-Maia JM. Sport psychiatry 2016: brain, mind, and medical-psychiatric care. *Int Rev Psychiatry*. 2016;28(6):545–546. doi:10.1080/09540261.2016.1218148
75. Loprinzi PD, Herod SM, Cardinal BJ, Noakes TD. Physical activity and the brain: a review of this dynamic, bi-directional relationship. *Brain Res*. 2013;1539:95–104. doi:10.1016/j.brainres.2013.10.004
76. Steinmo S, Hager-Johnson G, Shahab L. Bidirectional association between mental health and physical activity in older adults: whitehall II prospective cohort study. *Prev Med*. 2014;66:74–79. doi:10.1016/j.ypmed.2014.06.005
77. Vancampfort D, Firth J, Schuch FB, et al. Sedentary behavior and physical activity levels in people with schizophrenia, bipolar disorder and major depressive disorder: a global systematic review and meta-analysis. *World Psychiatry*. 2017;16(3):308–315. doi:10.1002/wps.v16.3
78. Stubbs B, Williams J, Gaughran F, Craig T. How sedentary are people with psychosis? A systematic review and meta-analysis. *Schizophr Res*. 2016;171(1–3):103–109. doi:10.1016/j.schres.2016.01.034
79. Scheewe TW, Jorg F, Takken T, et al. Low physical activity and cardiorespiratory fitness in people with schizophrenia: a comparison with matched healthy controls and associations with mental and physical health. *Front Psychiatry*. 2019;10:87. doi:10.3389/fpsy.2019.00087
80. Spartano NL, Davis-Plourde KL, Himali JJ, et al. Association of accelerometer-measured light-intensity physical activity with brain volume: the framingham heart study. *JAMA Netw Open*. 2019;2(4):e192745. doi:10.1001/jamanetworkopen.2019.2745
81. Ibanez V, Silva J, Cauli O. A survey on sleep assessment methods. *PeerJ*. 2018;6:e4849. doi:10.7717/peerj.4849
82. Prince SA, Adamo KB, Hamel ME, Hardt J, Connor Gorber S, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *Int J Behav Nutr Phys Act*. 2008;5:56. doi:10.1186/1479-5868-5-56
83. Dowd KP, Szeklicki R, Minetto MA, et al. A systematic literature review of reviews on techniques for physical activity measurement in adults: a DEDIPAC study. *Int J Behav Nutr Phys Act*. 2018;15(1):15.
84. Althoff T, Sosic R, Hicks JL, King AC, Delp SL, Leskovec J. Large-scale physical activity data reveal worldwide activity inequality. *Nature*. 2017;547(7663):336–339. doi:10.1038/nature23018
85. Services UDOHaH. *Physical Activity Guidelines for Americans*. 2nd. Washington, DC; 2018.
86. (WHO) WHO. Key facts: physical activity. 23 February 2018. Accessed 1 August, 2019.
87. Kinnunen H, Hakkinen K, Schumann M, Karavirta L, Westerterp KR, Kyrolainen H. Training-induced changes in daily energy expenditure: methodological evaluation using wrist-worn accelerometer, heart rate monitor, and doubly labeled water technique. *PLoS One*. 2019;14(7):e0219563. doi:10.1371/journal.pone.0219563
88. Merikangas KR, Swendsen J, Hickie IB, et al. Real-time mobile monitoring of the dynamic associations among motor activity, energy, mood, and sleep in adults with bipolar disorder. *JAMA Psychiatry*. 2018.
89. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollak CP. The role of actigraphy in the study of sleep and circadian rhythms. *Sleep*. 2003;26(3):342–392. doi:10.1093/sleep/26.3.342
90. Dauwan M, Begemann MJH, Slot MIE, Lee EHM, Scheltens P, Sommer IEC. Physical exercise improves quality of life, depressive symptoms, and cognition across chronic brain disorders: a transdiagnostic systematic review and meta-analysis of randomized controlled trials. *J Neurol*. 2019. doi:10.1007/s00415-019-09493-9

91. de Souto Barreto P. Prescription of physical activity. *Lancet*. 2013;381(9878):1623. doi:10.1016/S0140-6736(13)61019-3
92. Abrantes AM, Farris SG, Brown RA, et al. Acute effects of aerobic exercise on negative affect and obsessions and compulsions in individuals with obsessive-compulsive disorder. *J Affect Disord*. 2019;245:991–997. doi:10.1016/j.jad.2018.11.074
93. Hallgren M, Kraepelien M, Ojehagen A, et al. Physical exercise and internet-based cognitive-behavioural therapy in the treatment of depression: randomised controlled trial. *Br J Psychiatry*. 2015;207(3):227–234. doi:10.1192/bjp.bp.114.160101
94. Curcic D, Stojmenovic T, Djukic-Dejanovic S, et al. Positive impact of prescribed physical activity on symptoms of schizophrenia: randomized clinical trial. *Psychiatr Danub*. 2017;29(4):459–465. doi:10.24869/psyd.2017.459
95. Immonen T, Brymer E, Davids K, Liukkonen J, Jaakkola T. An ecological conceptualization of extreme sports. *Front Psychol*. 2018;9:1274. doi:10.3389/fpsyg.2018.01274
96. Di Lodovico L, Poulain S, Gorwood P. Which sports are more at risk of physical exercise addiction: a systematic review. *Addict Behav*. 2019;93:257–262. doi:10.1016/j.addbeh.2018.12.030
97. Grandner MA. Sleep, health, and society. *Sleep Med Clin*. 2017;12(1):1–22. doi:10.1016/j.jsmc.2016.10.012
98. Samson DR, Crittenden AN, Mabulla IA, Mabulla AZP. The evolution of human sleep: technological and cultural innovation associated with sleep-wake regulation among hadza hunter-gatherers. *J Hum Evol*. 2017;113:91–102. doi:10.1016/j.jhevol.2017.08.005
99. Sun BL, Wang LH, Yang T, et al. Lymphatic drainage system of the brain: a novel target for intervention of neurological diseases. *Prog Neurobiol*. 2018;163–164:118–143. doi:10.1016/j.pneurobio.2017.08.007
100. Miyazaki S, Liu CY, Hayashi Y. Sleep in vertebrate and invertebrate animals, and insights into the function and evolution of sleep. *Neurosci Res*. 2017;118:3–12. doi:10.1016/j.neures.2017.04.017
101. Navarro-Sanchis C, Brock O, Winsky-Sommerer R, Thuret S. Modulation of adult hippocampal neurogenesis by sleep: impact on mental health. *Front Neural Circuits*. 2017;11:74. doi:10.3389/fncir.2017.00074
102. Zhang J, Paksarian D, Lamers F, Hickie IB, He J, Merikangas KR. Sleep patterns and mental health correlates in US adolescents. *J Pediatr*. 2017;182:137–143. doi:10.1016/j.jpeds.2016.11.007
103. Zhai L, Zhang H, Zhang D. Sleep duration and depression among adults: a meta-analysis of prospective studies. *Depress Anxiety*. 2015;32(9):664–670. doi:10.1002/da.2015.32.issue-9
104. Taylor DJ, Lichstein KL, Durrence HH, Reidel BW, Bush AJ. Epidemiology of insomnia, depression, and anxiety. *Sleep*. 2005;28(11):1457–1464. doi:10.1093/sleep/28.11.1457
105. Winokur A. The relationship between sleep disturbances and psychiatric disorders: introduction and overview. *Psychiatr Clin North Am*. 2015;38(4):603–614. doi:10.1016/j.psc.2015.07.001
106. Estrada-Prat X, Alvarez-Guerrico I, Batlle-Vila S, et al. Sleep alterations in pediatric bipolar disorder versus attention deficit disorder. *Psychiatry Res*. 2019;275:39–45. doi:10.1016/j.psychres.2019.01.108
107. Reynolds CF 3rd, Kupfer DJ. Sleep research in affective illness: state of the art circa 1987. *Sleep*. 1987;10(3):199–215. doi:10.1093/sleep/10.3.199
108. Emslie GJ, Armitage R, Weinberg WA, Rush AJ, Mayes TL, Hoffmann RF. Sleep polysomnography as a predictor of recurrence in children and adolescents with major depressive disorder. *Int J Neuropsychopharmacol*. 2001;4(2):159–168. doi:10.1017/S1461145701002383
109. Steinsbekk S, Berg-Nielsen TS, Wichstrom L. Sleep disorders in preschoolers: prevalence and comorbidity with psychiatric symptoms. *J Dev Behav Pediatr*. 2013;34(9):633–641. doi:10.1019/97/01.DBP.0000437636.33306.49
110. McCurry SM, Reynolds CF, Ancoli-Israel S, Teri L, Vitiello MV. Treatment of sleep disturbance in alzheimer's disease. *Sleep Med Rev*. 2000;4(6):603–628. doi:10.1053/smr.2000.0127
111. Harvey AG, Talbot LS, Gershon A. Sleep disturbance in bipolar disorder across the lifespan. *Clin Psychol (New York)*. 2009;16(2):256–277. doi:10.1111/j.1468-2850.2009.01164.x
112. Monti JM, Monti D. Sleep disturbance in schizophrenia. *Int Rev Psychiatry*. 2005;17(4):247–253. doi:10.1080/09540260500104516
113. McCarthy MJ, Wei H, Nievergelt CM, et al. Chronotype and cellular circadian rhythms predict the clinical response to lithium maintenance treatment in patients with bipolar disorder. *Neuropsychopharmacology*. 2019;44(3):620–628. doi:10.1038/s41386-018-0273-8
114. Silvestri R, Gagliano A, Arico I, et al. Sleep disorders in children with Attention-Deficit/Hyperactivity Disorder (ADHD) recorded overnight by video-polysomnography. *Sleep Med*. 2009;10(10):1132–1138. doi:10.1016/j.sleep.2009.04.003
115. Vitiello MV, Borson S. Sleep disturbances in patients with alzheimer's disease: epidemiology, pathophysiology and treatment. *CNS Drugs*. 2001;15(10):777–796. doi:10.2165/00023210-200115100-00004
116. Jafari B, Mohsenin V. Polysomnography. *Clin Chest Med*. 2010;31(2):287–297. doi:10.1016/j.ccm.2010.02.005
117. Bloch KE. Polysomnography: a systematic review. *Technol Health Care*. 1997;5(4):285–305. doi:10.3233/THC-1997-5403
118. Paruthi S, Brooks LJ, D'Ambrosio C, et al. Recommended amount of sleep for pediatric populations: a consensus statement of the American s. *J Clin Sleep Med*. 2016;12(6):785–786. doi:10.5664/jcsm.5866
119. Consensus Conference P, Watson NF, Badr MS, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American academy of sleep medicine and sleep research society. *J Clin Sleep Med*. 2015;11(6):591–592. doi:10.5664/jcsm.4758
120. Sluggert L, Wagner SL, Harris RL. Sleep duration and obesity in children and adolescents. *Can J Diabetes*. 2019;43(2):146–152. doi:10.1016/j.cjcd.2018.06.006
121. Grandner MA. Sleep and obesity risk in adults: possible mechanisms; contextual factors; and implications for research, intervention, and policy. *Sleep Health*. 2017;3(5):393–400. doi:10.1016/j.sleh.2017.07.014
122. Liu Y, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of healthy sleep duration among adults—United States, 2014. *MMWR Morb Mortal Wkly Rep*. 2016;65(6):137–141. doi:10.15585/mmwr.mm6506a1
123. Ancoli-Israel S, Roth T. Characteristics of insomnia in the United States: results of the 1991 national sleep foundation survey. I. *Sleep*. 1999;22(Suppl 2):S347–S353.
124. Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. *Sleep Med Rev*. 2002;6(2):97–111. doi:10.1053/smr.2002.0186
125. Briguglio M, Gianturco L, Stella D, et al. Correction of hypovitaminosis D improved global longitudinal strain earlier than left ventricular ejection fraction in cardiovascular older adults after orthopaedic surgery. *J Geriatr Cardiol*. 2018;15(8):519–522. doi:10.11909/j.issn.1671-5411.2018.08.005
126. Vitale JA, Banfi G, La Torre A, Bonato M. Effect of a habitual late-evening physical task on sleep quality in neither-type soccer players. *Front Physiol*. 2018;9:1582. doi:10.3389/fphys.2018.01.582
127. Roveda E, Vitale JA, Bruno E, et al. Protective effect of aerobic physical activity on sleep behavior in breast cancer survivors. *Integr Cancer Ther*. 2017;16(1):21–31. doi:10.1177/1534735416651719
128. Sadeh A, Acebo C. The role of actigraphy in sleep medicine. *Sleep Med Rev*. 2002;6(2):113–124. doi:10.1053/smr.2001.0182

129. Sadeh A, Hauri PJ, Kripke DF, Lavie P. The role of actigraphy in the evaluation of sleep disorders. *Sleep*. 1995;18(4):288–302. doi:10.1093/sleep/18.4.288
130. Lomeli HA, Perez-Olmos I, Talero-Gutierrez C, et al. Sleep evaluation scales and questionnaires: a review. *Actas Esp Psiquiatr*. 2008;36(1):50–59.
131. Blake MJ, Blake LM, Schwartz O, et al. Who benefits from adolescent sleep interventions? Moderators of treatment efficacy in a randomized controlled trial of a cognitive-behavioral and mindfulness-based group sleep intervention for at-risk adolescents. *J Child Psychol Psychiatry*. 2018;59(6):637–649. doi:10.1111/jcpp.12018
132. Tanev KS, Winokur A, Pitman RK. Sleep patterns and neuropsychiatric symptoms in hospitalized patients with dementia. *J Neuropsychiatry Clin Neurosci*. 2017;29(3):248–253. doi:10.1176/appi.neuropsych.16090166
133. Maruani J, Geoffroy PA. Bright Light as a personalized precision treatment of mood disorders. *Front Psychiatry*. 2019;10:85. doi:10.3389/fpsy.2019.00085
134. Martin JL, Hakim AD. Wrist actigraphy. *Chest*. 2011;139(6):1514–1527. doi:10.1378/chest.10.1872
135. Jaehne A, Unbehaun T, Feige B, Lutz UC, Batra A, Riemann D. How smoking affects sleep: a polysomnographical analysis. *Sleep Med*. 2012;13(10):1286–1292. doi:10.1016/j.sleep.2012.06.026
136. Geoffroy PA, Micoulaud Franchi JA, Lopez R, Schroder CM; membres du consensus Melatonine S. The use of melatonin in adult psychiatric disorders: expert recommendations by the French institute of medical research on sleep (SFRMS). *Encephale*. 2019. doi:10.1016/j.encep.2019.04.068
137. Chennaoui M, Arnal PJ, Sauvet F, Leger D. Sleep and exercise: a reciprocal issue? *Sleep Med Rev*. 2015;20:59–72. doi:10.1016/j.smrv.2014.06.008
138. Hyun MK, Baek Y, Lee S. Association between digestive symptoms and sleep disturbance: a cross-sectional community-based study. *BMC Gastroenterol*. 2019;19(1):34. doi:10.1186/s12876-019-0945-9
139. Ogilvie RP, Lutsey PL, Widome R, Laska MN, Larson N, Neumark-Sztainer D. Sleep indices and eating behaviours in young adults: findings from project EAT. *Public Health Nutr*. 2018;21(4):689–701. doi:10.1017/S1368980017003536
140. Kruger AK, Reither EN, Peppard PE, Krueger PM, Hale L. Do sleep-deprived adolescents make less-healthy food choices? *Br J Nutr*. 2014;111(10):1898–1904. doi:10.1017/S0007114514000130
141. Katagiri R, Asakura K, Kobayashi S, Suga H, Sasaki S. Low intake of vegetables, high intake of confectionary, and unhealthy eating habits are associated with poor sleep quality among middle-aged female Japanese workers. *J Occup Health*. 2014;56(5):359–368. doi:10.1539/joh.14-0051-OA
142. Quante M, Khandpur N, Kontos EZ, Bakker JP, Owens JA, Redline S. “Let’s talk about sleep”: a qualitative examination of levers for promoting healthy sleep among sleep-deprived vulnerable adolescents. *Sleep Med*. 2018.
143. Bhat SP, Sharma A. Current drug targets in obesity pharmacotherapy - a review. *Curr Drug Targets*. 2017;18(8):983–993. doi:10.2174/1389450118666170227153940
144. Wolfe BM, Kvach E, Eckel RH. Treatment of obesity: weight loss and bariatric surgery. *Circ Res*. 2016;118(11):1844–1855. doi:10.1161/CIRCRESAHA.116.307591
145. Riemann D, Nissen C, Palagini L, Otte A, Perlis ML, Spiegelhalder K. The neurobiology, investigation, and treatment of chronic insomnia. *Lancet Neurol*. 2015;14(5):547–558. doi:10.1016/S1474-4422(15)00021-6
146. Porta M, Servello D, Zanaboni C, et al. Deep brain stimulation for treatment of refractory tourette syndrome: long-term follow-up. *Acta Neurochir (Wien)*. 2012;154(11):2029–2041. doi:10.1007/s00701-012-1497-8
147. Lojko D, Stelmach-Mardas M, Suwalska A. Is diet important in bipolar disorder? *Psychiatr Pol*. 2018;52(5):783–795. doi:10.12740/PP/OnlineFirst/78703
148. Aucoin M, LaChance L, Cooley K, Kidd S. Diet and psychosis: a scoping review. *Neuropsychobiology*. 2018;1–23. doi:10.1159/000493399
149. Owen L, Corfe B. The role of diet and nutrition on mental health and wellbeing. *Proc Nutr Soc*. 2017;76(4):425–426. doi:10.1017/S0029665117001057
150. Sanchez-Villegas A, Ara I, Guillen-Grima F, Bes-Rastrollo M, Varo-Cenarruzabeitia JJ, Martinez-Gonzalez MA. Physical activity, sedentary index, and mental disorders in the SUN cohort study. *Med Sci Sports Exerc*. 2008;40(5):827–834. doi:10.1249/MSS.0b013e31816348b9
151. Anderson KN, Bradley AJ. Sleep disturbance in mental health problems and neurodegenerative disease. *Nat Sci Sleep*. 2013;5:61–75. doi:10.2147/NSS.S34842
152. Zanaboni Dina C, Porta M. *Understanding Tourette Syndrome. A Guide to Symptoms, Management and Treatment*. Oxon: Routledge; 2020.
153. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med*. 2010;7(7):e1000316. doi:10.1371/journal.pmed.1000316
154. Briguglio M, Gianola S, Aguirre MFI, et al. Nutritional support for enhanced recovery programs in orthopedics: future perspectives for implementing clinical practice. *Nutr Clin Metab*. 2019;33(3):190–198. doi:10.1016/j.nupar.2019.04.002
155. Dell’Osso B, Benatti B, Hollander E, et al. Socio-demographic and clinical characterization of patients with Obsessive-Compulsive Tic-related Disorder (OCTD): an Italian multicenter study. *J Psychopathol*. 2018;24:148–153.
156. Alvarez-Alvarez I, Zazpe I, Perez de Rojas J, et al. Mediterranean diet, physical activity and their combined effect on all-cause mortality: the Seguimiento Universidad de Navarra (SUN) cohort. *Prev Med*. 2018;106:45–52. doi:10.1016/j.ypmed.2017.09.021
157. Leech RM, McNaughton SA, Timperio A. The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *Int J Behav Nutr Phys Act*. 2014;11:4. doi:10.1186/1479-5868-11-4
158. Jezewska-Zychowicz M, Gebiski J, Guzek D, et al. The associations between dietary patterns and sedentary behaviors in polish adults (lifestyle study). *Nutrients*. 2018;10(8). doi:10.3390/nu10081004
159. Tasali E, Chapotot F, Wroblewski K, Schoeller D. The effects of extended bedtimes on sleep duration and food desire in overweight young adults: a home-based intervention. *Appetite*. 2014;80:220–224. doi:10.1016/j.appet.2014.05.021
160. St-Onge MP, O’Keefe M, Roberts AL, RoyChoudhury A, Laferrere B. Short sleep duration, glucose dysregulation and hormonal regulation of appetite in men and women. *Sleep*. 2012;35(11):1503–1510. doi:10.5665/sleep.2198
161. St-Onge MP, Zuraikat FM. Reciprocal roles of sleep and diet in cardiovascular health: a review of recent evidence and a potential mechanism. *Curr Atheroscler Rep*. 2019;21(3):11. doi:10.1007/s11883-019-0772-z
162. Lang C, Brand S, Feldmeth AK, Holsboer-Trachsler E, Puhse U, Gerber M. Increased self-reported and objectively assessed physical activity predict sleep quality among adolescents. *Physiol Behav*. 2013;120:46–53. doi:10.1016/j.physbeh.2013.07.001
163. Kalak R, Gerber M, Kirov R, et al. Daily morning running for 3 weeks improved sleep and psychological functioning in healthy adolescents compared with controls. *J Adolesc Health*. 2012;51(6):615–622. doi:10.1016/j.jadohealth.2012.02.020
164. Yang PY, Ho KH, Chen HC, Chien MY. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. *J Physiother*. 2012;58(3):157–163. doi:10.1016/S1836-9553(12)70106-6

165. de Castro Toledo Guimaraes LH, de Carvalho LB, Yanaguibashi G, Do Prado GF. Physically active elderly women sleep more and better than sedentary women. *Sleep Med.* 2008;9(5):488–493. doi:10.1016/j.sleep.2007.06.009
166. Pizinger TM, Aggarwal B, St-Onge M-P. Sleep extension in short sleepers: an evaluation of feasibility and effectiveness for weight management and cardiometabolic disease prevention. *Front Endocrinol (Lausanne).* 2018;9:392. doi:10.3389/fendo.2018.00392
167. Ngandu T, Lehtisalo J, Solomon A, et al. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *Lancet.* 2015;385(9984):2255–2263. doi:10.1016/S0140-6736(15)60461-5
168. Bott NT, Hall A, Madero EN, et al. Face-to-face and digital multidomain lifestyle interventions to enhance cognitive reserve and reduce risk of alzheimer's disease and related dementias: a review of completed and prospective studies. *Nutrients.* 2019;11(9):2258. doi:10.3390/nu11092258
169. Adan RAH, van der Beek EM, Buitelaar JK, et al. Nutritional psychiatry: towards improving mental health by what you eat. *Eur Neuropsychopharmacol.* 2019. doi:10.1016/j.euroneuro.2019.10.011
170. Firth J, Siddiqi N, Koyanagi A, et al. The lancet psychiatry commission: a blueprint for protecting physical health in people with mental illness. *Lancet Psychiatry.* 2019;6(8):675–712. doi:10.1016/S2215-0366(19)30132-4
171. Winpenny EM, van Sluijs EMF, White M, Klepp KI, Wold B, Lien N. Changes in diet through adolescence and early adulthood: longitudinal trajectories and association with key life transitions. *Int J Behav Nutr Phys Act.* 2018;15(1):86. doi:10.1186/s12966-018-0719-8
172. Corder K, Winpenny E, Love R, Brown HE, White M, Sluijs EV. Change in physical activity from adolescence to early adulthood: a systematic review and meta-analysis of longitudinal cohort studies. *Br J Sports Med.* 2017.
173. Lund HG, Reider BD, Whiting AB, Prichard JR. Sleep patterns and predictors of disturbed sleep in a large population of college students. *J Adolesc Health.* 2010;46(2):124–132. doi:10.1016/j.jadohealth.2009.06.016

Neuropsychiatric Disease and Treatment

Dovepress

Publish your work in this journal

Neuropsychiatric Disease and Treatment is an international, peer-reviewed journal of clinical therapeutics and pharmacology focusing on concise rapid reporting of clinical or pre-clinical studies on a range of neuropsychiatric and neurological disorders. This journal is indexed on PubMed Central, the 'PsycINFO' database and CAS, and

is the official journal of The International Neuropsychiatric Association (INA). The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/neuropsychiatric-disease-and-treatment-journal>