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Chronotype Depression And Physical Activity: A Relationship To Be Studied?

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Abstract

Introduction: Preferences for certain times of day to perform daily activities have been the focus of several investigations. Individuals with evening preference exhibit higher scores for depressive symptoms and less involvement in physical activities compared to morning and intermediate chrono types. On the other hand, physical activity is an intervention that has shown great promise in alleviating symptoms of Major depressive disorder.

Evidence Acquisition: This study aimed to perform a narrative review of the available evidence of possible relationships between chrono type, depression and physical activities. The Electronic searches of the published literature were performed in the databases National Library of Medicine National Institutes of Health, in 2019, for the last five years in the adult population. The results were grouped into three categories, chrono type and depression in adults; depression and exercise/physical activity in adults; chrono type and exercise/physical activity/sport in adults.

Evidence Synthesis: the importance of physical activities in combating depression is quite evident in the literature, showing an inverse relationship between the level of physical activity and depressive symptoms.

Conclusions: However, many studies on depressive individuals do not identify the chrono type as an important tool to integrate chronobiological aspects of human behavior in the treatment of this disease. This review provides evidence for the scarcity of studies on the relationship between chrono type, depression and physical activity.

Keywords: Sepression; Chronotypes; Physical activity; Exercise; Adults; Sport

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Introduction

Circadian rhythmicity is present in a range of biological and behavioral functions in all species and every cell; there is an endogenous temporal mechanism capable of preparing the organism in advance for external oscillations such as in the light-dark cycle [1,2]. These endogenous diurnal variations are determined by our internal circadian clocks and external environmental cues called "zeitgebers". As examples of external environmental cues are the light/dark cycle and social interactions among others [3, 4].

The circadian timing system comprises the central clock in the suprachiasmatic nucleus (SCN) located in the hypothalamus and peripheral clocks in the body's peripheral tissues that are controlled by the so-called clock genes [5, 4, 6]. These circadian clocks are fixed, but undergo external stimulus adjustments including sunlight, food, stress, exercise and temperature [7]. Circadian rhythms vary among people and are mainly influenced by age, sex, hereditary and environmental influences [8, 3]. The variation of circadian rhythms among people may be classified with the concept of circadian typology called chronotype comprising three circadian types: the morning, the intermediate and the evening type [9, 3].

The term chronotype was initially used by Horne and Östberg to identify subjects with morning and evening preferences through the questionnaire called HO Morning / Evening, which has 19 questions with scores ranging from 16 to 86 points, the lowest scores are referring to people with afternoon characteristics and the highest scores refer to people with morning characteristics, where the afternoon will have a preference for the activities at late hours and the morning with a preference for the activities at early hours in the morning [10].

The importance for the investigation of chronotypes has grown quickly and it is now accepted that circadian preference is associated with physical and mental health, in terms of well-being, but also some diseases [11, 12, and 1]. Some studies have shown a relationship between evening chronotype and

depressive symptoms [13, 14, 15, and 12].

A major depressive disorder is a mental illness responsible for years of disability also is reflected as a list of risk factors with mortality and morbidity worldwide [16]. The official diagnosis of depression is subjective and rests on the documentation of a certain number of symptoms that significantly impair functioning for certain duration [17]. People with depression suffer from changes in body composition [18], sleep [19-21], cortisol levels [22, 23], and body temperature [24, 25]. It is important to explain the complex array of symptoms related to the circadian activity. Recent studies combining behavioral, molecular and electrophysiological techniques reveal those certain aspects of depression result from maladaptive stress in specific neural circuits.

Multiple research reports suggest that abnormalities in circadian rhythms are involved in the etiopathogenesis of mood disorders [26]. Due to the increasing number of cases of people with depression, several studies seek alternatives for the prevention and treatment of depression. For reference [26] the pharmacological, psychological, and light treatments of mood disorders have multiple effects on circadian function. Effects of antidepressant drugs on the free-running circadian period indicate that these medications affect the circadian pacemaker. Antidepressants are considered the first line of treatment; however, the response rate is considered low. Circadian rhythm and altered physical activity have long been recognized as core features of Major depression. Thus, physical activity has been suggested as non-pharmacological treatments that should complement traditional methods [27-31].

In this sense, it is important to expand a discussion on the relationship between chronotype, depression, and physical activity. Understanding whether there is a relationship between the type of chronotype and depression, as well as whether physical activity can minimize these effects, is extremely important for the general health of the population suffering from depressive symptoms. Therefore, this study aimed to review the available evidence of possible relationships between chronotype, depression and physical activity. The evening types show more depressive symptoms than the morning ones. Thus, this study hypothesizes that physical activity can positively modulate responses of symptoms of depression in morning and afternoon patients.

Materials and Methods

Four comprehensive surveys were performed at the National Library of Medicine (Pubmed) in 2019, with the first combination using the terms: "Depression AND Chronotype AND (exercise OR physical activity) AND adults". However, only 7 results were found and did not present the relationship between the three variables [Physical Activity, chronotype and depression]. In this sense, the searches were separated (Figure 1), initially with the following terms "Chronotype AND depression AND adults", being 139 articles identified. Inclusion criteria were: original articles; written in English; last 5 years; the relationship between depression and chronotype. Later the terms were used: "Depression AND (exercise OR physical activity) AND adults". In all, 2790 articles were found. Selection criteria were: written in English, original study; last 5 years; the relationship between exercise and physical activity with depression in adults. The last search used the following keywords: Chronotype AND (exercise OR physical activity OR sports) AND adults. In all 58 articles were found, the following criteria were applied: original article; written in English; present the relationship between chronotype and physical activity.

Analysis procedures

During the first screening, two reviewers (MJ or LT) evaluated the titles and abstracts of each citation and excluded irrelevant studies. For each potential study, two reviewers (FL or EL) examined the full article and assessed whether the studies fit within the inclusion criteria. In case of disagreement, a third evaluator would be contacted (NL).

Quality Assessment

The articles were evaluated based on internal validity (selection bias, performance bias, friction measurement bias and reports) and the validity construct (adequacy of the operational criteria used). In general, the quality of the evidence from the studies was assessed using three main measures: 1 limitation (poorly designed design, for example); 2- consistency of results; and 3- accuracy (ability to generalize findings and provide sufficient data). Studies that failed at these points were not added or selected (**Figure 1)**.

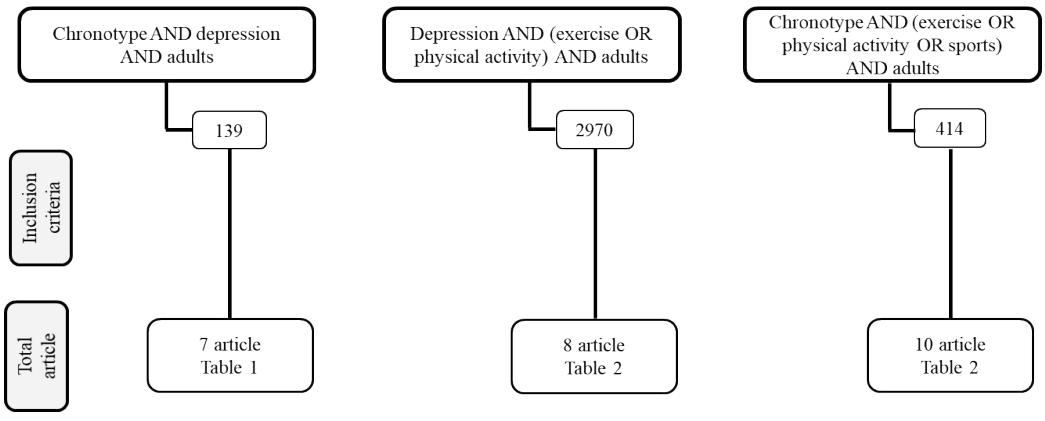

Figure 1 Flowchart of studies selection.

Results

As a result of the first search, which identifies the relationship between chronotype and depression in adults, 7 studies were selected (Table I). The second search made it possible to identify the relationship between exercise / physical activity and depression in adults. At the end of the analyzes, 8 articles were selected (Table II). In the third search, we found 10 studies that evaluate the relationship of chronotype with exercise / physical activity in adults (Table III). Since the instruments developed to estimate chronotype are not equal the specific instrument used has been indicated in the tables **(Tables 1-3)**.

The relationship between depression and Chronotype in adults

The evening is among people that exhibited more symptoms of depression than the morning and intermediate types [15, 32-40], but the underlying mechanism is still unclear. A possible reason could be the transformation of our modern society into a technological society that does not take into account the importance of chronotype on human health. Nowadays, many people spend an increasing amount of time in front of computer screens mainly during night time and these habit changes can force people to become more evening. Exposure to blue light from computer and cell phone screens can lead to disturbances in melatonin secretion and alterations in circadian physiology, alertness, and cognitive performance levels.

Among patients undergoing cognitive-behavioral therapy [41] those characterized as evening types have significantly more depressive symptoms, insomnia and irregular sleep-in relation to the intermediate and morning patients. A meta-analysis [42]

Table 1. Summary of studies involving Chronotype and depression in adults.

Authors	Objective	Sample	Depression Assessment	Chronotype Assessment	Relevant Results
(Reference 48)	To report suicidality according to chronotype and seasonal pattern in patients with MDD.	120 subjects (18 to 74years old).	HAMD	MEQ	There was no significant difference in depression scores between morning and evening patients. However, patients with evening preference have a higher suicidal risk when compared to morning patients.
(Reference 47)	To understand the associations between different dimensions of chronotype, depressive symptoms, and emotional eating.	10000 subjects (25-74 years old).	CES-D	Original MEQ	Preferences for morning hours were associated with lower scores of depressive symptoms.
(Reference 36)	To study the relationship between chronotype and depression in a more representative sample size of the Finnish adult population.	10503 subjects	Self-report questionnaires, with four questions.	MEQ	The evening show more depressive symptoms than the morning ones, even after controlling for possible confounding factors (sex, age, education, living conditions, alcohol consumption, smoking and sleep).
(Reference 33)	To examine the association between chronotypes and the presence of depressive and anxiety disorders in a large cohort, while taking into account relevant Sociodemographic, somatic health, and sleep factors.	2596 participated in the second year.	MDD and IDS	MCTQ	Individuals with evening chronotype are more likely to have depressive disorder, even when adjusted for health factors, Sociodemographic data, and sleep-related factors.
(Reference 32)	To explore the role of cognitive reactivity and pathological worry in the association between eveningness and depression.	1654 subjects, being 1227 depressions and 427 healthy controls.	LEIDS-R	MCTQ	Results show that evening type scored higher on a specific psychological factor of vulnerability to depression.
(Reference 49)	To examined whether differential relation of depression and seasonality to the morning and evening components of morningness-eveningness might be confirmed in analyses of a big dataset.	2398 subjects	CES-D	A short (40-item) version SWPAQ	Depression was found to be significantly linked to earliness-lateness, but only morning component of earliness-lateness demonstrates such a link.
		Siberia.			
(Reference 38)	The purpose of this study was to investigate and analyze the role of depression in its effects on chronotype and sociality.	2772 men	PHQ-9	CSM	Depressive symptoms and suicidal tendencies are significantly related to individuals with evening chronotype when compared to morning.
		2860 women			

Table 2. Summary of studies involving Exercise/Physical Activity and depression in adults.

Authors	Objective	Sample	Depression Assessment	Exercise Or	Relevant Results
				Physical Activity	
(Reference 59)	To Evaluate The Efficacy Of Four Months Of Aerobic Exercise Intervention In A Group Of Women Referred By Psychiatrists.	26 Women Diagnosed With Clinical Depression.	Bdi-Ii	Intervention 8-Week, 3 Times-Weekly, One Hour Each Session.	The Exercise Group When Compared To The Control Group Showed Improvement In Relation To Depression Parameters, And Higher Physical Fitness.
(Reference 60)	To Examine The Efficacy Of A Self-Selected Intensity Aerobic Exercise Intervention In Outpatients With Depression, Assessing Depressive Symptoms As Well As Physical Fitness.	46 Outpatients Diagnosed With	Hrsd-17	Ukk2-Km Walk Test To Estimate Physical Fitness. Intervention 8-Week, 3 Times-Weekly, One-Hour Long Group Interventions On Monday, Wednesday And Friday Evenings.	There Were Major Changes In The Depression Scores Assessed By The Hamilton Scale And Moderate Changes In The Bdi-Ii Assessment.
		Mild To Severe Depression.	And Bdi-Ii.		
(Reference 58)	Clarify Whether Depressive Symptoms Moderate The Relations Between Exercise And Same-Day Self-Efficacy, And Between Self-Efficacy And Next-Day Exercise.	116 Subjects Physically Inactive, Being 75,9% Women.	Ces-D	Were Collected Every Day: (Today Did You Walk For At Least 10 Minutes At A Time At Your Normal Walking Pace, While At Work, For Recreation, To Get To And From Places, Or For Any Other Reason?)	The Study Found That Self-Efficacy Was Higher On Days Exercise Occurred Compared With Days On Which It Did Not Occur. Second, We Found That Self-Efficacy On Day X Predicted Greater Odds Of Exercise On Day X+1. Thus, These Findings Self-Efficacy On One Day Predicts The Likelihood Of Exercising The Next Day, Regardless Of Depressive Symptoms.
(Reference 63)	To Examine Independent And Combined Associations Of Pa And Sb With Depressive Symptoms Among Japanese Adults	2914 Subjects.	Using The Japanese Version Of Ces-D.	Ipaq-Sv	Physical Activity Is Related To Lower Risk Of Depressive Symptoms Independently. In Addition, Active People Have Fewer Depressive Symptoms Compared To High Sedentary Behavior.
(Reference 61)	Prospectively Assess The Association Between Self-Reported Habitual Physical Activity Levels And Depression Severity Following A 12-Week Intervention	629 Subjects, Being 75% Women.	Phq-9	Adopted A Questionnaire And Score Conversion Method To Assess Habitual Physical Activity. The Questionnaire Was Developed By The Swedish School Of Sport And Health Science.	Subjects With Higher Levels Of Physical Activity Responded Favorably To Treating Depression When Compared To Those Who Are Less Active.

identified that both short and long sleep duration is related to the increase in depressive symptoms in people characterized as evening types [42]. Short duration, mainly due to increased daytime tiredness [43], while, and long sleep duration due to decreased physical activity [44].

Regarding well-being satisfaction, evening types have less satisfaction with life and are subject to developing psychiatric problems [45]. Dissatisfaction occurs mainly because evening people need to adapt to morning routines which causes an imbalance between personal and external rhythms. The time of taking antidepressants can also clarify this relationship since medications taken at night can cause an excitatory effect and delaying sleep onset. As a consequence, people wake up earlier than they would like favoring changes to the internal clock46. Besides [33] investigated those subjects characterized as evening tend to report variation in daytime mood, with the morning time being the period of greatest instability, these changes leave the subjects exposed to negative feelings that favor depression.

Our search demonstrates a lack of consensus in the literature on the type of chronotype and the increase in symptoms of

Table 3. Summary of studies involving Chronotype and Exercise/Physical Activity in adults.

Authors	Objective	Sample	Chronotype Assessment	Exercise Or	Relevants Results
				Physical Activity	
(Reference 85)	The Aim Of This Study Was To Measure The Response Of Morning Cyclists To A Standardized Bout Of Exercise Performed At Different Times Of The Day.	20 Cyclists Who Were Categorized As Morning.	Mepq	All The Cyclists Had Participated In Recreational Cycle Races For The Past 2 Years And Trained At Least Twice Per Week. In Addition, These Cyclists Had Completed A Local, Annual 109 Km Cycle Race, Or A Similar Event, In Less Than 4 H Within The Past 2 Years	Cyclists Classified As Morning, Submitted To The Same Physical Effort (Load And Intensity), At Different Times Of The Day, Demonstrate Higher Perception Of Effort, In Other Words, It's More Difficult To Perform The Task At Night When Compared To The Execution In The Morning Period.
(Reference 86)	The First Aim Was To Assess The Effect Of Marathon Start Time On Chronotype In Marathon Runners. The Second Aim Was To Determine The Extent To Which Either A High Level Of Physical Activity Or Climate Explains The Bias Towards Morningness Observed In South African Athletes And Controls. The Third Aim Was To Determine Whether Any Relationship Exists Between Chronotype, Per3vntr Polymorphism Genotype, Training Habits And Marathon Performance.	381 Caucasian Male Marathon Runners (South African-Dutch)	Meq	Training History Data Included Actual And Preferred Training Time-Of-Day Information On Weeks Days And Weekends, As Well As Training Duration, Intensity And Distance (Run Groups); While Race History Data Included Personal Best Marathon And Half-Marathon Times.	There Was Predominance In The Morning In Two Situations. When Comparing A Group Of South African Runners With Dutch Runners; Also When Comparing The Group Of Runners (South Africans And Dutch) With Their Respective Control Groups.
(Reference 88)	To Extend The Current Evidence Base By Exploring How Sport Participation And Ptlid Relate To Chronotype Amplitude; To Explore How Chronotype Relates To Various Characteristics Of Sport Training And Competition; To Explore The Independent And Interrelated Contribution Of Sport Participation And Chronotype To Ptlid.	Sample Included 976 Non-Athletes (493 Women And 483 Men) And 974 Athletes (478 Women And 496 Men).	Caen Chronotype	Participants Completed A Battery Of Questionnaires Targeting Sport Participation Characteristics, Six Positive Ptlid.	Sport Participation Characteristics (Time Of Competition And Duration Of Training Sessions) Were Related To Chronotype Amplitude And Morningness–Eveningness. But Most Notable Was That Sport Participation Was Related To Amplitude But Not To Morningness-Eveningness.
			Questionnaire		
(Reference 87)	To Compare 200 M Swimming Time-Trial (Tt) Performance, Rate Of Perceived Exertion And Mood State At 06h30 And 18h30 In Trained Swimmers	26 (18 Men And 8 Women) Trained Caucasian Swimmers (25-50 Years Old)	Meq	The Swimmers Performed A 200 M Freestyle Tt At Either 06:30 A.M And 6:30 P.M. Each Session Was Separated By A Minimum Of 3 Days To Allow For Recovery.	The Results Show That Swimmers Who Trained In The Morning Were Faster In The Time Trial In The Morning, While Those Who Trained At Night Were Faster In The Test At Night. However, There Was No Difference Between Morning And Evening Performance When The Swimmers Were Considered As A Single Group.

depression. Some studies found an association between higher depression scores to the evening chronotype. A large cohort study using the Munich Chronotype Questionnaire found an association of depressive and/or anxiety disorders with late chronotype after adjusting for Sociodemographic, somatic health, and sleep-related factors [33]. Also, the same research group demonstrated that depress genic cognitions are more prevalent in the evening suggesting a possible link between chronotype and depression [32]. Another research carried out in Finland, showed that the night chronotype is related to depression, in a sample with an age range of [25-74] years old, and the association remains after controlling for sex, age, education, living conditions, consuming alcohol, smoking and sleep36. A Finnish population-based study showed that morning preference and high alertness in the morning were associated with lower scores of depressive symptoms and emotional eating47. The first two studies used the Munich Chronotype Questionnaire that measures the phase of sleep positions for both free and working days whereas the later used Morningness–Eveningness Questionnaire that evaluates the phase preferences of individual behavior over a 24h day. Reference48 also studied patients diagnosed with major depressive disorder. There was a relationship between suicide risk in the evening chronotype and hypomanic personality traits. The risk of suicide was also observed in university students with symptoms of depression at night. Suicide risk was also observed in university students with symptoms of depression and evening chronotype [38]. Depression was also found to be significantly associated with earliness-lateness, but only the morning component of earliness-lateness demonstrates such association [49].

Physical activity and depression in adults

The benefits of physical exercise / physical activity programs are pointed out as important tools in the treatment of depression. Although the mechanisms are still quite confusing, some hypotheses move towards the anti-inflammatory effect that physical exercise promotes [50], such as lower levels of interleukin-6 (IL-6) and C-reactive protein [51].

Others point to the fact that depressed individuals have a decrease in hippocampus neurogenesis, in this sense [52], points out the antidepressant effect of exercise on the capacity that it has to increase the hippocampus neurogenesis, which occurs due to a possible increase in endorphins –b [53] also, by the increase in the brain-derived neurotropic factor (BDNF), which are responsible for neural development and survival [54].

There are also physiological mechanisms that justify the relationship between physical activity and changes in the hypothalamic-pituitary-adrenal axis (HPA) in depressed individuals [55], in hormonal changes in serotonin [56] and noradrenaline levels [57]. However, physical exercise is capable of promoting changes in the function of HPA55, capable of causing changes in the levels of serotonin [56], and noradrenaline [57].

The literature points out those depressive individuals tend not to be involved in physical activity programs; therefore, psychological factors influence the responses of the activity/exercise effect on the treatment of depression. Reference [58] observed that self-efficacy, that is, the individual's ability to perform a certain behavior, is related to the start of a physical exercise program by people with high symptoms of depression self-efficacy during interventions in people with depression.

There is confusion between the role of habitual physical activity and physical exercise as a dose-response for the treatment of depression. Reference [59] demonstrated that 16 weeks of aerobic exercise of light to moderate intensity is sufficient to decrease the symptoms of depression, anxiety and stress, and positive changes in the physical fitness of depressed patients compared to the control group. Also, aerobic physical exercise causes an antidepressant effect regardless of intensity, a fact observed by reference [60] in which the subject chose the intensity of the exercise session and at the end of 8 weeks there was a significant improvement in symptoms. In this sense, coaches must know the importance of performing the exercise in psychological aspects and not worry only about physiological changes.

Despite the studies that seek to explain the relationship between the level of physical activity and depressive symptoms present a significant number of subjects; a major limitation of these studies is that they assess physical activity through questionnaires [61-65]. The results demonstrate a reduction in depressive symptoms with increased levels of physical activity.

Other studies have already investigated the relationship between physical activity and depression using different measurement variables. Physical activity was included in the routine of patient visits for 14 weeks and an increase in the number of steps/day monitored by a pedometer was observed, the study suggests that physical activity be included in the treatment of depression [27].

Reference [66] compared three forms of treatment for depression [antidepressant/exercise / behavioral therapy after 12 weeks, all of which had significant improvement in symptoms. Also, in the elderly, it was identified that antidepressant medication is effective for a response fast, but after 16 weeks of aerobic exercise [70-85% HR reserve], per- forming three weekly sessions, the effects on depression levels are comparable to the use of medication and the use of medication plus exercise [67].

Physical activity was also associated with improvements in depression scores in a study that monitored women for 32 years (1974-2005). Depression scores and physical activity were measured in the years 1974, 1992, 2000 and 2005. The authors conclude that the higher the depression scores the lower the level of physical activity and over the years the decrease in physical activity also pointed to an increase in depression scores [68].

In addition to regular physical activity, sedentary behavior, that is, the daily time spent performing sedentary activities is also related to depression. Reference [69] compared the average time that men and women with an average age of 64 years, spend watching TV, and noticed that people who spend six or more hours a day watching TV have higher depression scores when compared to people who stay less than 2 hours a day. In children and adolescents, the longer the screen time, that is, sedentary behavior, the greater the risk of developing depression, with the

lowest risk being observed in less than one hour/day and the risks are significantly increased above two hours/day [70].

Evaluated in adults the time spent in physical activities and the time in sedentary activities, using an accelerometer, the study concluded that the increase in depressive symptoms is related to the decrease in light physical activity and increase in sedentary behavior [71].

There is also evidence that the total weekly energy expenditure (EE) is related to depression scores. Men and women were divided into a group with a GE of 7kcal / kg/week and an EE group of 17.5kcal / kg/week (public health dose), both groups subdivided into 3 and 5 times a week of aerobic exercise on a bicycle in the laboratory, beyond the control group (flexibility exercises 3 times a week). Groups with EE within the recommended for health, after 12 weeks of training, showed a significant reduction in depression scores, while the other two groups showed values similar to the control group [72].

Another study with 9580 men was evaluated for depressive scores and level of physical activity, with the following groups: inactive (0 MET • min • week−1), low (1-499 MET • min • week−1), medium (500-999 MET • min • week−1) and high (≥1000 MET • min • week−1). When comparing the inactive group with the low, medium and high groups, the probability of developing depression is 24%, 51% and 51%, respectively [73].

Several review articles and Meta analyzes were also published to clarify the relationship between physical exercise and physical activity with depression [61,74-77]. However, it is not still unclear, the ideal dose of physical activity / physical exercise that should be "ad- ministered" daily or at intervals of days for the treatment of depression, nor if the reduction of the time allocated to sedentary activities would be enough to prevent or treat depression.

Physical activity and Chronotype in adults

The estimates that 1 in 4 adults don't meet the global needs for physical activity. That is, even with all the global campaigns and recommendations for regular physical activity, as a strategy for the prevention and treatment of diseases as people who don't perform or are necessary. Besides, as changes in countries' economic patterns, the sedentary lifestyle, (greater access to transport, technology and urbanization) [78].

Strategies must be implemented to break the barriers (lack of motivation, time, energy and adequate equipment) that prevent people from starting and staying in physical activity programs [79]. In this sense, identifying the chronotype profile of sedentary individuals can contribute to these individuals starting an exercise program. That is, the time to perform physical activity should be linked to that individual's preference period, increasing the probability of activities happening [80].

Our findings show that the studies that evaluated the relationship between chronotype and physical activity are mostly transversal, and present many methodological differences, such as the profile of the subjects, exercise models, instruments to characterize chronotype and physical activity, factors that make it difficult to compare studies.

Subjects characterized as morning people have an independent relationship with the frequency of self-reported exercise [80]. Morning people also show less perceived effort during a walking activity performed in the morning when compared to nighttime exercise in the morning [81]. Furthermore, morning people have significantly more physical activity than evening and intermediate [82]. Also, the evening profile shows a reduced amount of physical activity and greater involvement in sedentary activities, monitored by accelerometer [83]. These findings were also observed84, in which the evening showed a lower amount of physical activity and more time sitting in minutes/day, assessed by questionnaire when compared to the morning ones.

Reference [84], also observed that when separating the investigated sample and evaluating only the working subjects, all chronotypes show less physical activity when compared to the morning. The authors point out those evening subjects difficult to do physical activities in the morning or afternoon periods. And the evening periods they are usually in work activities or studies, while in the morning people find it easier to do activities, so they tend to be more active.

In groups of athletes such as cyclists with a morning chronotype, they had a greater perception of effort in performing activities in the afternoon/night when compared to exercises in the same load and intensity performed in the morning85. Already, when comparing the type of chronotype, of a group of South African runners and with Dutch runners, there was morning predominance in South Africans, also the greater number of morning runners when comparing runners (South Africans and Dutch) with sedentary control groups (South African and Dutch). In addition, the best personal brands in half marathons and marathons for South African runners were achievements in morning tests86. Usually, runners wake up early to train and this is associated with preferences for realizing activities. In swimmers, the morning chronotype was associated with lower fatigue scores, better time against the clock, and lower perceived effort scores [87].

Another relevant point is the results found in88, in which, in addition to determining the type of chrono- type of the evaluated subjects, they characterize the amplitude of each individual's chronotype. Amplitude is characterized as a component of circadian rhythm and is related to the ability to tolerate an unpleasant situation [8]. In the study by reference [88], Involvement in sports activities was related to the chronotype amplitude, but not to the type.

A specific group of people (Live in the Arctic Circle) [89] observed that after a physical exercise program, VO2max had a smaller increase in morning subjects when compared to the evening. However, the larger increase in their strength indexes is better in the type morning when compared to the type evening. It is important to highlight that few studies address this theme and the influence of the environment with little external light and the behavior of each chronotype.

Physical activity, Chronotype and depression in adults

The relationship between physical activity, chronotype and

depression has not been extensively studied in the adult population. In this review, we identified that most studies that relate to two of the three variables studied are cross-sectional; the assessment of physical activity is done in a subjective way, as well as depression, which is based on the use of a questionnaire and not a clinically diagnosed sample. However, some studies that did not present the keywords used in our research seek to clarify some possible explanations for this relationship.

A randomized control trial study with evening types used practical interventions including light exposure, fixed meal times, caffeine intake, and exercise to shift the late timing of evening types to an earlier time. The phase advance of 2 h in evening types improved self-reported depression and stress, isometric grip strength performance, and reaction time suggesting a simple strategy to improve mental wellbeing and performance [90]. As recently observed by [91], autography data showed reduced physical activity levels and daily rhythm disturbances among people with depressive and anxiety disorders. Using a less frequent measure of chronotype, the sleep midpoint on free days, the authors did show an association between evening chronotype with physical activity and depression. The strength of this work was the assessment of sleep and physical activity by actigraphy [91].

In a study of preclinical medical students, evening chronotype was associated with less happiness in comparison to the morning-type and intermediate-type individuals. Also, depression and physical activity were among the factors that predict happiness among Turkish preclinical medical students [92]. Another survey, also with medical students from China, found that nocturnal types perform little physical activity, a lot of sedentary behavior and make a greater intake of drinks with caffeine [93].

Recently [94], investigated the social jetlag of workers and related it to different variables [physical activity, depression, lifestyle, work routine]. It was observed that the largest social jetlag was related to people with a type evening chronotype, with the highest scores of depression scores, and poor sleep quality characteristics observed in women, young people, blue collar workers and those who use smoking, but they were also physically active both at work and at leisure.

Precise mechanisms linking chronotype, depression and physical activity are unclear. The relationship between depression and chronotype can be explained by the relationship between the sleep-wake circadian cycle and the secretion of neurotransmitters, such as serotonin, noradrenaline and dopamine [95]. We know that in the modern lifestyle, this relationship is influenced by the pace of life of people, high level of physical and psychological stress, due to extensive work hours and sleep deprivation. As well as the relationship between physical activity and depression, as physical activity increases the levels of serotonin, dopamine and norepinephrine in the hippocampus region, which increases the feeling of well-being However, in relation to chronotype and physical activity, it seems that the main characteristics are in the fact that morning type individuals tend to be more active, the relationship can be clarified by the fact that these subjects do not have problems waking up early, and that is why they are able to better adapt the routine, work/study with time for exercise. The types evening is unable to wake up early and generally the night have no time available because they are involved in work and/or study.

However, with the increase in the number of people diagnosed with depression, with the current situation experienced in the world, longitudinal investigations are urgently needed to monitor people clinically diagnosed with depression, submitted to physical exercise programs, appropriate to preference schedules, to clarify the relationship between these variables, as well as to better prescribe physical exercise to prevent and minimize the effects caused by depression.

Conclusion

The influence of chronotype on performance and on the general health of individuals and on the relationship with metabolic diseases has been investigated. However, further studies are needed to establish the specific relationship between chronotype, physical activity and depression. In our review, we found that many studies indicate that higher depression scores and lower levels of physical activity are found mainly in evening or intermediate types. What makes it difficult to compare is the fact that researches do not distinguish whether this relationship can be influenced by the depression classification of the investigated subjects, or by the characteristics of the physical exercise [intensity, volume and physical exercise] performed. Other factors that were not considered in the studies are sleeping, eating, working and the time of physical activity.

Understand the pattern of preferences [morning or evening] of the subjects and the current routine of life [hours at work / study] can be important mechanisms to start a physical activity program, promoting improvement in general health. Furthermore, the importance of physical activity in combating depression is quite evident and suggested by the literature. However, the explanations of the possible physiological and psychological mechanisms that influence this relationship are still under investigation.

Simple strategies to improve mental wellbeing by targeting circadian disruption without the need for pharmacological agents can be used in the treatment of depression. Identifying the chronotype in individuals with depression can be the first step to start a chronobiological intervention including the time of physical activity, meal time, sleep/awake cycles that will improve mental wellbeing. Despite the need for further research, this remains an exciting prospect for a large number of people that suffer from reduced mental well-being.

References

1 Mukherji A, Bailey SM, Staels B, Baumert TF (2019) The circadian clock and liver function in health and disease. J Hepatol 71:200-211.

2 Roenneberg T, Merrow M (2016) The circadian clock and human health. Curr Biol 26:R432-R443.

3 Roenneberg T Daan S, Merrow M (2003) The art of entrainment. J Biol Rhythms 18:183-194.

4 Vieira E, Burris TP, Quesada I (2014) Clock genes, pancreatic function, and diabetes. Trends Mol. Med 20:685-693.

5 Mohawk JA, Green CB, Takahashi JS (2012) Central and peripheral circadian clocks in mammals. Annu Rev Neurosci 35:445-462.

6 Vieira E, Ruano EG, Figueroa ALC, Aranda G, Momblan D et al. (2014) Altered clock gene expression in obese visceral adipose tissue is associated with metabolic syndrome. PloS one 9:e111678.

7 Tahara Y, Aoyama S, Shibata S (2017) The mammalian circadian clock and its entrainment by stress and exercise. J Physiol Sci 67:1-10.

8 Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V et al. (2012) Circadian typology: a comprehensive review. Chronobiology international. 29:1153-1175.

9 Granada AE, Bordyugov G, Kramer A, Herzel H (2013) Human chronotypes from a theoretical perspective. PLoS One 8:e59464.

10 Horne JA, Östberg O (1976) A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Chronobiol Int

11 Basnet S, Merikanto I, Lahti T, Männistö S, Laatikainen T (2017) Associations of common noncommunicable medical conditions and chronic diseases with chronotype in a population-based health examination study. Chronobiology International. 34:462-470.

12 Kivelä L, Papadopoulos MR, Antypa N (2018) Chronotype and psychiatric disorders. Curr Sleep Med Rep 4:94-103.

13 Au J, Reece J (2017) The relationship between chronotype and depressive symptoms: a meta-analysis. J Affect Disord 218:93-104.

14 Fares S, Hermens DF, Naismith SL, White D, Hickie IB et al. (2015) Clinical correlates of chronotypes in young persons with mental disorders. Chronobiology international 32:1183-1191.

15 Hidalgo MP, Caumo W, Posser M, Coccaro SB, Camozzato AL, Chaves MLF (2009) Relationship between depressive mood and chronotype in healthy subjects. Psychiatry Clin Neurosci 63:283-290.

16 Hallgren M, Stubbs B, Vancampfort D, Lundin A, Jaakallio P et al. (2017) Treatment guidelines for depression: greater emphasis on physical activity is needed. Eur Psychiatry 40:1-3.

17 Krishnan V, Nestler E (2008) The molecular neurobiology of depression. Nature 455: 894–902.

18 Becofsky KM, Sui X, Lee D-c, Wilcox S, Zhang J et al. (2015) A prospective study of fitness, fatness, and depressive symptoms. Am J Epidemiol 181:311-320.

19 Franzen PL, Buysse DJ (2008) Sleep disturbances and depression: risk relationships for subsequent depression and therapeutic implications. Dialogues Clin Neurosci 10:473.

20 Murphy MJ, Peterson MJ (2015) Sleep disturbances in depression. Sleep Med Clin 10:17

21 Nutt D, Wilson S, Paterson L (2008) Sleep disorders as core symptoms of depression. Dialogues Clin Neurosci 10:329.

22 Dedovic K, Ngiam J (2015)The cortisol awakening response and major depression: examining the evidence. Neuropsychiatr Dis Treat 11:1181–1189.

23 Qin D-d, Rizak J, Feng X-l, Yang S-c, Lü L-b, et al. (2016) Prolonged secretion of cortisol as a possible mechanism underlying stress and depressive behaviour. Sci Rep 6:30187.

24 Hanusch K-U, Janssen CH, Billheimer D, Jenkins I, Spurgeon E, et al. (2013) Whole-body hyperthermia for the treatment of major depression: associations with thermoregulatory cooling. Am J Psychiatry 170:802-804.

25 Janssen CW, Lowry CA, Mehl MR, Allen JJ, Kelly KL, et al. (2016) Whole-body hyperthermia for the treatment of major depressive disorder: a randomized clinical trial. JAMA Psychiatry 73:789-795.

26 Sher L (2003) Etiology, pathogenesis, and treatment of seasonal and non-seasonal mood disorders: possible role of circadian rhythm abnormalities related to developmental alcohol exposure. Med Hypotheses 62:797–801.

27 Adams DJ, Remick RA, Davis JC, Vazirian S, Khan KM (2015) Exercise as medicine—the use of group medical visits to promote physical activity and treat chronic moderate depression: a preliminary 14-week pre–post study. BMJ Open SEM 1:e000036.

28 Choi KW, Zheutlin AB, Karlson RA, Wang MJ, Dunn EC, et al. (2020) Physical activity offsets genetic risk for incident depression assessed a electronic health records in a biobank cohort study. Depress Anxiety 37:106-114.

29 Park JE, Lee JY, Kim BS, Kim KW, Chae SH, et al. (2015) Above-moderate physical activity reduces both incident and persistent late-life depression in rural Koreans. Int J Geriatr Psychiatry 30:766-775.

30 Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB, et al. (2018)Physical activity and incident depression: a meta-analysis of prospective cohort studies. Am J Psychiatry 175:631-648.

31 Schuch FB, Vancampfort D, Sui X, Rosenbaum S, Firth J, et al. (2016) Are lower levels of cardiorespiratory fitness associated with incident depression? A systematic review of prospective cohort studies. Prev Med 93:159-165.

32 Antypa N, Verkuil B, Molendijk M, Schoevers R, Penninx BW, et al. (2017) Associations between chronotypes and psychological vulnerability factors of depression. Chronobiol Int 34:1125-1135.

33 Antypa N, Vogelzangs N, Meesters Y, Schoevers R, Penninx BW (2016) Chronotype associations with depression and anxiety disorders in a large cohort study. Depress Anxiety 33:75-83.

34 Kitamura S, Hida A, Watanabe M, Enomoto M, Aritake-Okada S, et al. (2010)Evening preference is related to the incidence of depressive states independent of sleep-wake conditions. Chronobiol Int 27:1797-1812.

35 Levandovski R, Dantas G, Fernandes LC, Caumo W, Torres I, et al. (2011) Depression scores associate with chronotype and social jetlag in a rural population. Chronobiol Int 28:771-778.

36 Merikanto I, Kronholm E, Peltonen M, Laatikainen T, Vartiainen E, et al (2015) Circadian preference links to depression in general adult population. J Affect Disord 188:143-148.

37 Merikanto I, Lahti T, Kronholm E, Peltonen M, Laatikainen T, et al. (2013) Evening types are prone to depression. Chronobiol Int 30:719-725.

38 Park H, Lee H-K, Lee K (2018) Chronotype and suicide: the mediating effect of depressive symptoms. Psychiatry Res 269:316-320.

39 Prat G, Adan A (2013) Relationships among circadian typology, psychological symptoms, and sensation seeking. Chronobiol Int 30:942-949.

40 Roaldset JO, Linaker OM, Bjorkly S (2012) Predictive validity of the MINI suicidal scale for self-harm in acute psychiatry: a prospective study of the first year after discharge. Arch Suicide Res 16:287-302.

41 Ong JC, Huang JS, Kuo TF, Manber R (2007) Characteristics of insomniacs with self-reported morning and evening chronotypes. J Clin Sleep Med 3:289-294.

42 Zhai L, Zhang Y, Zhang D (2015) Sedentary behaviour and the risk of depression: a meta-analysis. Br J Sports Med. 49:705-709.

43 Shen J, Barbera J, Shapiro CM (2006) Distinguishing sleepiness and fatigue: focus on definition and measurement. Sleep Med Rev 10:63-76.

44 Stranges S, Dorn JM, Shipley MJ, Kandala N-B, Trevisan M et al. (2008) Correlates of short and long sleep duration: a cross-cultural comparison between the United Kingdom and the United States: the Whitehall II Study and the Western New York Health Study. Am J Epidemiol 168:1353-1364.

45 Diaz-Morales JF, Jankowski KS, Vollmer C, Randler C (2013) Morningness and life satisfaction: further evidence from Spain. Inter Chronobiol 30:1283-1285.

46 Knapen SE, Riemersma-Van der Lek RF, Antypa N, Meesters Y, Penninx BW et al. (2018) Social jetlag and depression status: results obtained from the Netherlands Study of Depression and Anxiety. Inter Chronobiol 35:1-7.

47 Konttinen H, Kronholm E, Partonen T, Kanerva N, Mannisto S et al. (2014) Morningness-eveningness, depressive symptoms, and emotional eating: a population-based study. Inter Chronobiol. 31:554-563.

48 Bahk Y-C, Han E, Lee S-H (2014) Biological rhythm differences and suicidal ideation in patients with major depressive disorder. J Affect Disord 168:294-297.

49 Putilov AA (2018) Associations of depression and seasonality with morning-evening preference: comparison of contributions of its morning and evening components. Psychi res 262:609-617.

50 Gleeson M, Bishop NC, Stensel DJ, Lindley MR, Mastana SS et al. (2011) The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. Nat Rev Immunol 11:607-615.

51 Kohut M, McCann D, Russell D, Konopka D, Cunnick J (2006) Aerobic exercise, but not flexibility/resistance exercise, reduces serum IL-18, CRP, and IL-6 independent of β-blockers, BMI, and psychosocial factors in older adults. Brain, behavior, and immunity 20:201-209.

52 Ernst C, Olson AK, Pinel JP, Lam RW, Christie BR (2006) Antidepressant effects of exercise: evidence for an adult-neurogenesis hypothesis? J Psychiatry Neurosci.

53 Persson AI, Thorlin T, Bull C, Zarnegar P, Ekman R (2003) Mu-and delta-opioid receptor antagonists decrease proliferation and increase neurogenesis in cultures of rat adult hippocampal progenitors. Eur J Neurosci 17:1159-1172.

54 Cotman CW, Berchtold NC (2002) Exercise a behavioral intervention to enhance brain health and plasticity. Trends neurosci 25:295-301.

55 Wittert G, Livesey J, Espiner E, Donald R (1996) Adaptation of the hypothalamopituitary adrenal axis to chronic exercise stress in humans. Med Sci Sports Exerc 28:1015-1019.

56 Jacobs BL (1994) Serotonin motor activity and depression-related disorders. Am Scient 82:456-463.

57 Dishman RK (1997) Brain monoamines, exercise, and behavioral stress: animal models. Med Sci Sports Exerc.

58 Kangas JL, Baldwin AS, Rosenfield D, Smits JA, Rethorst CD (2015) Examining the moderating effect of depressive symptoms on the relation between exercise and self-efficacy during the initiation of regular exercise. Health Psych 34:556.

59 Carneiro LS, Fonseca AM, Vieira-Coelho MA, Mota MP, Vasconcelos-Raposo J (2015) Effects of structured exercise and pharmacotherapy vs. pharmacotherapy for adults with depressive symptoms.

60 Doose M, Ziegenbein M, Hoos O, Reim D, Stengert W et al. (2015) Self-selected intensity exercise in the treatment of major depression: a pragmatic RCT. Int J Psychiatry Clin Pract 19:266-275.

61 Hallgren M, Herring MP, Owen N, Dunstan D, Ekblom O et al. (2016) Exercise, physical activity, and sedentary behavior in the treatment of depression: broadening the scientific perspectives and clinical opportunities. Frontie psychia 7:36.

62 Kim S-Y, Jeon S-W, Shin D-W, Oh K-S, Shin Y-C (2018) Association between physical activity and depressive symptoms in general adult populations: an analysis of the dose-response relationship. Psychiatry Res 269:258-263.

63 Liao Y, Shibata A, Ishii K, Oka K (2016) Independent and combined associations of physical activity and sedentary behavior with depressive symptoms among Japanese adults. IJBM 23:402-409.

64 Porras-Segovia A, Rivera M, Molina E, Lopez-Chaves D, Gutiérrez B et al. (2019) Physical exercise and body mass index as correlates of major depressive disorder in community-dwelling adults: Results from the PISMA-ep study. J Affect Disord 251:263-269.

65 Wassink-Vossen S, Collard R, Hiles S, Voshaar RO, Naarding P (2018) The reciprocal relationship between physical activity and depression: Does age matter? European Psychiatry 51:9-15.

66 Hallgren M, Kraepelien M, Lindefors N, Zeebari Z, Kaldo V et al. (2015) Physical exercise and internet-based cognitive–behavioural therapy in the treatment of depression: randomised controlled trial. B J Psych 207:227-234.

67 Blumenthal JA, Babyak MA, Moore KA, Craighead WE, Herman S et al. (1999) Effects of exercise training on older patients with major depression. Arch Intern Med 159:2349-2356.

68 Gudmundsson P, Lindwall M, Gustafson DR, Ostling S, Hällström T (2015) Longitudinal associations between physical activity and depression scores in Swedish women followed 32 years. Acta Psychiatrica Scandinavica 132:451-458.

69 Hamer M, Stamatakis E (2014) Prospective study of sedentary behavior, risk of depression, and cognitive impairment. Med Sci Sports Exerc 46:718.

70 Liu M, Wu L, Yao S (2016) Dose response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. Br J Sports Med 50:1252-1258.

71 Helgadottir B, Forsell Y, Ekblom O (2015) Physical activity patterns of people affected by depressive and anxiety disorders as measured by accelerometers: a cross-sectional study. PloS one. 10:e0115894.

72 Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO (2005) Exercise treatment for depression: efficacy and dose response. Am J Prev Med 28:1-8.

73 Sieverdes JC, Ray BM, Sui X, Lee D-C, Hand GA, Baruth M, Blair SN (2012) Association between leisure time physical activity and depressive symptoms in men. Med Sci Sports Exerc 44:260-265.

74 Blake H (2012) Physical activity and exercise in the treatment of depression. Frontiers in Psychiatry. 3:106.

75 Deslandes A, Moraes H, Ferreira C, Veiga H, Silveira H et al. (2009) Exercise and mental health: many reasons to move. Neuropsycho 59:191-198.

76 Mathersul DC, Rosenbaum S (2016) The roles of exercise and yoga in ameliorating depression as a risk factor for cognitive decline. Evidence-Based Complementary and Alternative Medicine.

77 Schuch FB, Morres ID, Ekkekakis P, Rosenbaum S, Stubbs B (2017) A critical review of exercise as a treatment for clinically depressed adults: time to get pragmatic. Acta neuropsychiatrica 29:65-71.

78 Organization WH (2018) Global action plan on physical activity 2018-2030: more active people for a healthier world: at-a-glance World Health Organization.

79 Trost SG, Owen N, Bauman AE, Sallis JF, Brown W (2002) Correlates of adults' participation in physical activity: review and update. Med Sci Sports Exerc 34:1996-2001.

80 Hisler GC, Phillips AL, Krizan Z (2017) Individual differences in diurnal preference and time-of-exercise interact to predict exercise frequency. Ann Behav Med 51:391-401.

81 Rossi A, Formenti D, Vitale JA, Calogiuri G, Weydahl A (2015) The effect of chronotype on psychophysiological responses during aerobic self-paced exercises. Perceptual and Motor Skills. 121:840-855.

82 Suh S, Yang H-C, Kim N, Yu JH, Choi S (2017) Chronotype differences in health behaviors and health-related quality of life: a population-based study among aged and older adults. Behav Sleep Med 15:361-376.

83 Gubelmann C, Heinzer R, Haba-Rubio J, Vollenweider P, Marques-Vidal P (2018) Physical activity is associated with higher sleep efficiency in the general population. the CoLaus study Sleep 41:zsy070.

84 Wennman H, Kronholm E, Partonen T, Peltonen M, Vasankari T, Borodulin K (2015) Evening typology and morning tiredness associates with low leisure time physical activity and high sitting. Chronobi inter 32:1090-1100.

85 Kunorozva L, Roden LC, Rae DE (2014) Perception of effort in morning-type cyclists is lower when exercising in the morning. J Sports Sci 32:917-925.

86 Henst RH, Jaspers RT, Roden LC, Rae DE (2015) A chronotype comparison of South African and Dutch marathon runners: The role of scheduled race start times and effects on performance. Chronob intern 32:858-868.

87 Rae DE, Stephenson KJ, Roden LC (2015) Factors to consider when assessing diurnal variation in sports performance: the influence of chronotype and habitual training time-of-day. Eur J Appl Physiol 115:1339-1349.

88 Laborde S, Guillen F, Dosseville F, Allen MS (2015) Chronotype, sport participation, and positive personality-trait-like individual differences. Chronobiol inter 32:942-951.

89 Vitale JA, Weydahl A (2017) Chronotype, physical activity, and sport performance: a systematic review. Sports Medicine 47:1859-1868.

90 Facer-Childs ER, Middleton B, Skene DJ, Bagshaw AP (2019) Resetting the late timing of 'night owls' has a positive impact on mental health and performance. Sleep medicine 60:236-247.

91 Difrancesco S, Lamers F, Riese H, Merikangas KR, Beekman AT et al. (2019) Sleep circadian rhythm, and physical activity patterns in depressive and anxiety disorders: A 2-week ambulatory assessment study. Depre anxi 36:975-986.

92 Tan MN, Mevsim V, Pozlu Cifci M, Sayan H, Ercan AE (2020) Who is happier among preclinical medical students: the impact of chronotype preference. Chronobiol Intern 1-10.

93 Zhang Y, Xiong Y, Dong J, Guo T, Tang X et al. (2018) Caffeinated drinks intake, late chronotype, and increased body mass index among medical students in Chongqing, China: a multiple mediation model. Int J Environ Res Public Health 15:1721.

94 Islam Z, Hu H, Akter S, Kuwahara K, Kochi T et al. (2020) Social jetlag is associated with an increased likelihood of having depressive symptoms among the Japanese working population: the Furukawa Nutrition and Health Study. Sleep 43:zsz204.

95 Salgado-Delgado R, Tapia Osorio A, Saderi N, Escobar C (2011) Disruption of circadian rhythms: a crucial factor in the etiology of depression. Depres res treat.

96 He S-B, Tang W-G, Tang W-J, Kao X-L, Zhang C-G et al. (2012) Exercise intervention may prevent depression. Int J Sports Med 33:525-530.