MOOD DISORDERS (E BACA-GARCIA, SECTION EDITOR)

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Ecological Momentary Assessment and Mood Disorders in Children and Adolescents: a Systematic Review

Itziar Baltasar-Tello[1] · Carolina Miguélez-Fernández[2] · Inmaculada Peñuelas-Calvo[2] · Juan J. Carballo[1]

Abstract

Purpose of Review The aim of the present review is to systematically examine published data regarding ecological momentary assessment (EMA) in children and adolescents with mood disorders.

Recent Findings EMA is increasingly used to collect participant's information in their real environment and in real time. There are multiple studies focused on the evaluation of mood disorders in children and adolescents, but only a few of them used EMA protocols.

Summary Results found in this review showed a wide variability of works with different fields of study, methodological approaches, and EMA protocols. More than 60% of EMA studies in children and adolescents with mood disorders were conducted via phone call, showing high completion rates with data missing in 5 to 11.5% of the calls. Length of studies varied from a 4-day EMA protocol to a maximum of 8 weeks. Positive and negative affect, daily activities, and social context were the main EMA measures. Despite the limited number of studies using EMA in children and adolescents with mood disorders, EMA was useful in assessing mood symptoms in the moment and in patients' real-life environment. Studies also showed high completion and satisfaction rates. Although web pages and apps use have been increasing over the past years, the evidence base is still scarce. Future studies can facilitate understanding of EMA methodology among youth with mood disorders.

Keywords EMA · Mood disorders · Children · Adolescents · Mobile technologies

Introduction

Mood disorders are one of the most prevalent mental illnesses in children and adolescents. The National Health and Nutrition Examination Survey [1] found that 2.8% of children aged 8–11 years and 4.8% of adolescents aged 12–15 years had a mood disorder. Mood disorders are a major public health problem, not only due to their substantial prevalence but also because of the deleterious impact they have on functioning and vital high risk among subjects suffering from these conditions [2]. Furthermore, depression is the main cause

contributing to the global burden of disease among individuals aged 10–24, causing even more severe consequences for individuals and society than violence, road traffic accidents, and infectious and parasitic diseases. Bipolar disorder is also associated with a substantial impact and it is considered the fourth leading cause of global burden of disease among population aged 10–24 [3].

Though there are multiple differences that set children and adolescents apart from adults in mental health assessment, the same diagnostic criteria used for adults are commonly applied to evaluations of mood disorders among the pediatric population. These differences are considerable and depend on the developmental stage of the patient at the time of assessment [4].

In addition to the patient interview, other sources of information on the mental health of children and adolescents are needed, especially from parents and teachers. Information regarding life events, early development and infancy, and psychosocial functioning should be collected. Transversal and longitudinal information obtained during the evaluation are equally relevant to a diagnosis and determine the most

appropriate treatment for the patient, making the accuracy of this information of vital importance. Nonetheless, information obtained during clinical encounters can be biased by multiple factors, one of the most relevant being recall bias [5].

When patients are asked about their mood over the previous weeks or months, clinicians usually obtain responses based on a subjective summary of patient's past experiences. However, there is empirical evidence suggesting that recall of mood states depends on multiple factors such as cognitive styles or individual differences, and especially in patients with depression, the recall of negative affect (NA), negative experiences, and exaggeration of symptom severity are greater than in non-depressed controls [6].

The vast majority of studies conducted so far in population under 18 years of age evaluate mood disorders retrospectively [7]. Both longitudinal and cross-sectional studies are based on assessments that are hampered by recall bias. To meet this challenge, advances in electronic technologies have created new opportunities to adapt mental health evaluations and treatments to societal changes [8••].

Ecological momentary assessment (EMA) studies the relationship between individual experiences, social environments, and behaviors [9]. According to Shiffman et al., these "in the moment" measurements provide methodological advantages compared over traditional systems. First, they reduce recall bias by providing immediate information about current or recent experiences. They also provide data collected in individuals' natural environment, increasing reliability and compliance. Finally, repeated measurement in real environments and in the moment makes it possible to detect experience variations over time, which can be measured and evaluated in the search for patterns. Ecological momentary assessment will be possible if participants provide self-reports on immediate past or current experiences in their real environment, so compliance is a major factor to take into account. Multiple studies have evaluated mood symptoms in adults using EMA protocols [10], though few have taken this approach to assess mood disorders in children and adolescents.

Technological advances over the past 20 years have introduced new services geared toward patients with mental illness. These interventions have been used to facilitate the evaluation of symptoms in patients' real environment but also to provide virtual reality treatments as psychoeducation [11, 12], promoting therapy homework, or monitoring mood symptoms [13].

In terms of the evaluation of mental disorders, interventions using EMA protocols have been conducted through various different approaches, including via phone call, web page or applications, or digital reminders prompting patients to fill out forms.

The aim of the present work is to review published data regarding EMA in children and adolescents with mood disorders and evaluate results following usefulness, feasibility, and acceptability criteria.

Methods

The present review followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [14].

Search Process and Procedure In December 2017, our group conducted a systematic search using the PsychInfo, PubMed, and Google scholar databases to gather relevant studies. The following logical algorithm was employed: ("ecological momentary assessment" OR "experience sampling" OR "diary") AND ("affective disorder" OR "mood disorder" OR "depression" OR "bipolar disorder") AND ("children" OR "infant" OR "adolescent" OR "adolescence"). We also included studies which were not found in our search but were cited in other articles and met the abovementioned criteria. We only included studies in English language.

Types of Publications This systematic review included case reports, clinical trials, comparative studies, letters, meta-analysis validation studies, and prospective studies conducted on human subjects. Systematic reviews were excluded.

Inclusion Criteria We only included studies with participants under 18 years of age who met the clinical criteria for MDD or bipolar disorder according to the American Psychiatric Association DSM-IV classification (2000) [15]. We were interested in either studies that followed a cellular phone EMA protocol in which participants were interviewed by phone call, studies using a website or mobile application to answer the protocol questions, or those that required that patients fill out forms, for which there was a digital reminder (Fig. 1).
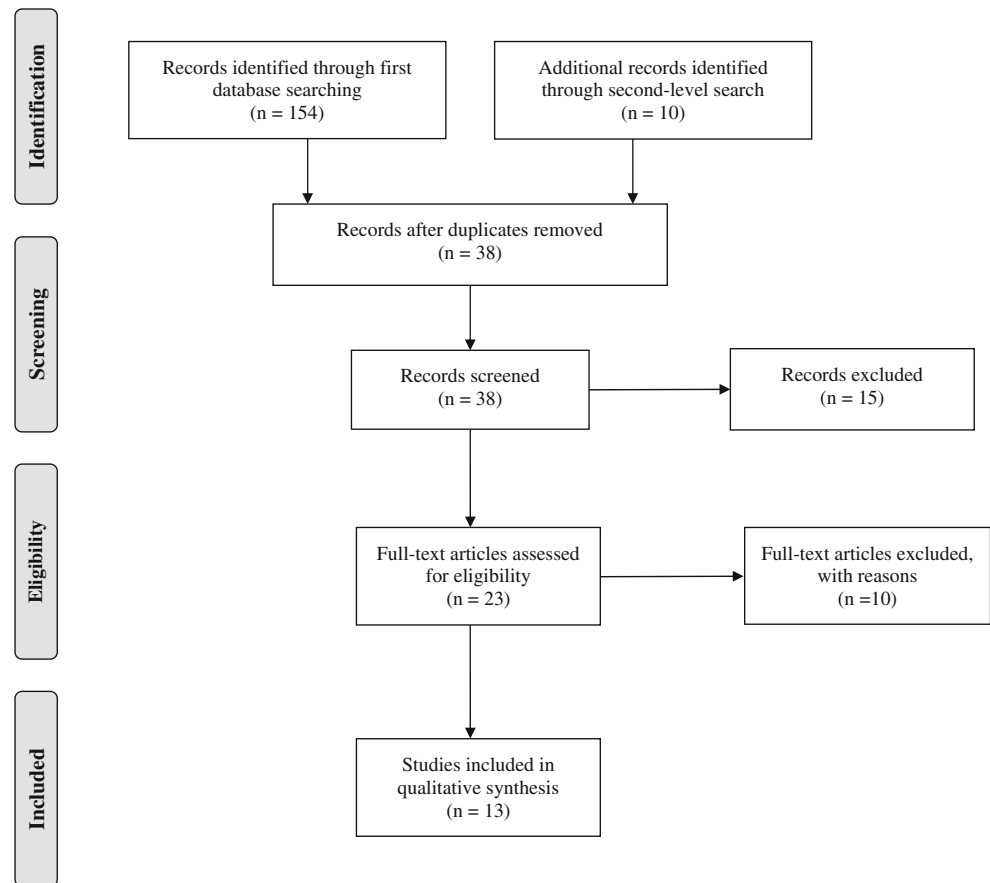
Exclusion Criteria We excluded studies that evaluated mood states but did not include a mood disorder diagnosis. We reviewed the full articles included in this review after examining the titles and abstracts.

Results

The search process yielded more than 100 papers matching our search criteria. Most were related to the adult population, and a few included assessment of mood states but did not meet the criteria for mood disorders or did not use approved scales for the assessment of mood symptoms. A significant number of them targeted school populations and measured mood states in the context of situations or events occurring in their natural environment.

Two of the researchers (IB, CM) conducted a careful review of the full articles. Thirteen papers were finally included (Table 1). For the sake of clarity, analysis will be divided into three sections appearing below: cell phone EMA protocol,

Fig. 1 Flow diagram of the inclusion of the studies from the literature search (PRISMA flow diagram)

Identification

Screening

Eligibility

Included

Records identified through first database searching
(n = 154)

Additional records identified through second-level search
(n = 10)

Records after duplicates removed
(n = 38)

Records screened
(n = 38)

Records excluded
(n = 15)

Full-text articles assessed for eligibility
(n = 23)

Full-text articles excluded, with reasons
(n = 10)

Studies included in qualitative synthesis
(n = 13)

web page/mobile app EMA protocol, and form-fill protocols with digital reminders.

Cell Phone EMA Protocol

Most of the articles found in our search followed an EMA protocol based on telephone interviews conducted by trained professionals.

The majority of these papers are based on the same study conducted at the University of Pittsburgh and analyze different aspects of patients with affective disorders. Participants were assessed and diagnosed with a mood disorder using the K-SADS-PL version [29]. The duration of the studies varied from 4 days to 8 weeks. The protocol was very similar in each article: participants received phone calls from trained staff at different times of the day, from Friday through Monday. Participants were interviewed about mood symptoms, stressors, sleep, and current companions.

Axelson et al. [16] conducted a pilot study using EMA methodology via phone calls in 2003. They recruited 21 adolescents; 16 of them met criteria for an affective disorder and 5 were controls. The study was conducted over 8 weeks with a total of 60 calls. Subjects were called 12 times every weekend between 4 p.m. Friday and 10 p.m. Monday. They were asked for activity at the moment of the call, social context, mood,

media use, and "things they are looking forward to doing" as well as negative anticipated activities and significant events. They also wore an actigraph to collect movement data and mark events as bedtime and wake-up time. Seventeen of the 21 participants completed the 8-week protocol and were able to complete it in a variety of environments (trips, relative's house, etc.). Call length was generally short, around 3 min. They demonstrated that EMA protocol was feasible and able to capture variability in patients with affective disorders.

Forbes et al. [19] analyzed links between positive mood and reward-related brain function in real environments using a phone EMA protocol. A group of 15 adolescents with major depressive disorder and a control group of 28 participants with no history of psychiatric disorders were evaluated by completing a functional magnetic resonance task associated with a monetary reward and completing a mood questionnaire (PANAS-C) administered via phone call to assess positive affect. Their subjective positive affect was evaluated during a 4-day cell phone EMA protocol consisting of a total of 12 calls. The authors found functional brain differences related to subjective positive affect in patients with major depressive disorder. These findings support the idea of altered reward processing and less positive affect in depressed youths. In terms of EMA adherence, data were missing or incomplete for 5% of calls.

Table 1   Characteristics of publications of ecological momentary assessment (EMA) in adolescents with mood disorders included in review ($N = 13$)

Reference	Sample	Hypothesis/goal	Measures	EMA protocol	EMA measures
Axelson et al. [16]	16 children with affective disorders and 5 healthy controls Mean age, 14.43 43% females	Examine EMA methodology in a sample of adolescents with mood disorders (preliminary results from a larger study)	K-SADS-Present and Lifetime version PANAS-C	8 weeks 12 phone calls	Activity, social context, mood ratings, and media use anticipated future activities and significant events
Bickham et al. [17••]	126 adolescents Mean age, 14.04 46.8% females	Assessment of different types of media use and symptoms of depression	TUDs Beck Depression Inventory for primary care limits media questions	1 week following enrollment. Additional week. 4–7 signals/day completing questionnaire	Activities, media use and context
Cousins et al. [18]	$n = 94$ $n = 23$ (only anxiety) $n = 42$ (MDD only $n = 13$ and MDD with anxiety $n = 29$) $n = 29$ (healthy controls) Mean age, 11.73 53% female	Examine relationship between affect and sleep in adolescents with mood disorders	K-SADS-PL Family history interview PANAS-C Actigraphy	First 2 weeks of an 8-week protocol 24 calls	Affect, behavior, context, sleep/wake cycle
Forbes et al. [19]	43 participants $n = 15$ with MDD (70% females) $n = 28$ controls (75% females) Mean age, 13.5	Analyze links between positive mood and reward-related brain function in real environments	SCARED MFQ fMRI paradigm PANAS-C Pubertal development (physical examination)	4 days 12 calls	Affect
Forbes et al. [20]	$n = 66$ MDD with anxiety ($n = 31$), MDD only ($n = 12$), or anxiety only ($n = 23$). Mean age, 12.08 60% females	Evaluation of treatment response in adolescents with MDD, anxiety, or comorbid MDD and anxiety	K-SADS-PL PANAS-C, 20 items CGI-S	8 weeks (CBT, SSRI or combination)	Affect, activities, and companions
Frost et al. [21]	353 adolescents Mean age, 15.13 56% females	Evaluate gender differences and depressive symptoms in patients with mood disorders	CES-D Positive and negative mood states (EMA)	1 week 56 beeps	Thoughts, negative and positive mood states, companions, and activities
Mor et al. [22]	278 adolescents	Examine within-day fluctuations in negative affect and relationship in self-focus	SCID CSR	3 days, 6 times a day	Thoughts, affect, and level of stress
Primack et al. [23]	MDD with anxiety ($n = 34$), only MDD ($n = 12$), and healthy controls ($n = 60$). 63.2% females Mean age = 12.7	Assessment of the association between media use and major depressive disorder	Schedule for Affective Disorders and Schizophrenia for School-Age Children- Present and Lifetime version 5 types of media (tv, music, video games, newspapers/magazines, books)	60 telephone calls 5 extended weekends 8-week period	Type of media use
	$n = 20$ MDD $n = 22$ controls		Pupil dilatation		Positive and negative affect

Table 1 (continued)

Reference	Sample	Hypothesis/goal	Measures	EMA protocol	EMA measures
Silk et al. [24]		Examine pupil dilatation and pupillary responses to emotional stimuli in children with depression			
Silk et al. [25]	n = 79, n = 47 with MDD, n = 32 controls, Mean age = 12.60, 64.58% females	Daily emotional dynamics of child and adolescent depression	K-SADS-PL, Family history interview, PANAS-C, Pubertal development (physical examination, Tanner staging), Social context	8 weeks, 60 calls	Emotions ratings, current activity, location, and social companion
Vandeleur et al. [26••]	214 probands and 389 offspring, Mean age of offspring at first assessment, 4.4 years, 52.4% females	Assessment of the familial aggregation and risk factors of mood disorders	Direct semi-structured diagnostic interviews, Neurocognitive testing, Anthropomorphic measures, Biochemical exams, Structural magnetic resonance imaging assessments of physical activity	Electronic diary, 4 times a day, 1-week period	Daily life activities, emotions, stress, sleep, and food intake
Waller et al. [27]	n = 60 (29 with MDD and 31 controls), Mean age, 14.7, 71.7% females, 28.3% males	Examine co-rumination during interactions with peers and parents in adolescents with MDD	MFQ, K-SADS-PL, 27-item CRQ	3 weeks, 42 calls	Behavior, social context, and emotional responding
Whalen et al. [28]	N = 30 MDD, 23 healthy controls, Mean age, 12.44, 64.15% females	Relationship between caffeine consumption and affect/sleep in youth with depression	SCID, Subjective sleep ratings, PANAS-C	EMA baseline and over 8 weeks, 60 calls	Behavior, affect, and social context

CES-D Center for Epidemiological Studies Depression Scales, CRQ Co-rumination Questionnaire, CSR Clinical Severity Rating, K-SADS-PL The Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime version, MFQ Mood and Feelings Questionnaire, PANAS-C Positive and Negative Affect Scale for Children, SCARED Childhood Anxiety and Related Disorders, SCID Structured Clinical Interview-Lifetime for DSM-IV, TUDs Time Use Diaries

The same group of researchers [20] used ecological momentary assessment to predict pharmacological treatment response in a sample of youth with depressive and anxiety disorders. In their study, the authors also examined the predictive validity of EMA compared to self-reported depressive (MFQ) and anxiety (SCARED) symptoms to predict symptom severity trajectory over the course of the treatment. Patients were interviewed via phone call about their affect and current companions in an 8-week protocol from Friday afternoon through Monday night, with a total of 12 phone calls each week. Calls on weekdays occurred after school hours. During the EMA calls, participants were asked about companions, what they were doing at the time, and current affect; these categories were assessed using the PANAS-C questionnaire. Participants were asked to rate each item from 1 (very slightly or not at all) to 5 (extremely). The first call of each day included the 20 PANAS-C items; all other calls included only four positive and four negative items used to compute mean NA (negative affect), PA (positive affect), and PA:NA scores. In this case, missing data were reported for 11.5% of calls; equipment problems accounted for 1.7% of missing data and attrition for 4%. The authors demonstrated the utility of EMA measures of affect compared to subject self-reporting when predicting treatment responses, especially in terms of NA and PA:NA. The researchers demonstrated that higher PA, lower NA, and a higher PA:NA ratio predicted lower severe anxiety and depressive symptoms after the treatment. In terms of companions, they also found that spending more time with family members before treatment was correlated with less severity of symptoms at the end of the treatment compared to more time spent with peers.

In other measures obtained by the same study at the University of Pittsburgh, Cousins et al. [18] conducted a follow-up study where 94 youth aged 8–16 years with a mood disorder and/or anxiety and a control group were evaluated using the same cell phone EMA protocol. The authors hypothesized that bidirectional relationships would be found between affect and sleep in all diagnostic groups. They also used the K-SADS-PL version (K-SADS-PL, Kaufman et al. [29]) for assessment and diagnosis and conducted cell phone evaluations at 4-day intervals over 8 consecutive weeks (analysis of this paper includes the first 2 weeks), for a total of 24 calls. They also used actigraphs to provide an estimation of sleep/wake cycle given via movement. They demonstrated that there are different patterns of bidirectional relationships between affect and sleep depending on three groups: MDD group, anxiety group, and controls. Although it was not possible to include analysis of the group with only MDD, it was interesting to demonstrate that depressive symptoms may be driving the affect/sleep relationship. This study did not include data on EMA participation or percentage of calls answered by the patients.

In 2007, Jennifer Silk [24] conducted a study of 20 participants with major depressive disorder between 8 and 17 years

of age to assess pupil reactivity to emotional stimuli. They used a phone-based EMA protocol to assess positive and negative affect in their natural environment, demonstrating that all the groups showed pupil dilatation after negative words, but those with MDD showed diminished late dilatation compared to the control group. In 2011, Silk et al. [25] expanded the aims and the sample of the study and included patients with MDD undergoing cognitive behavioral therapy and/or pharmacological treatment compared to a control group. They also used a phone-based EMA protocol. The analysis showed that EMA was a feasible method for assessing depressive symptoms in an 8-week follow-up. Patients with MDD presented greater depressive symptoms, lower PA:NA ratio, and more intense negative affect compared with control youths. Although patients with MDD had progressive outcomes, PA:NA did not change over the follow-up period. The average call time was 3.78 min. Call completion was 55 of 60 calls (92%), a rate showing similar compliance reported in other EMA studies. Missing data because of equipment problems or disruption of cell phone service was rare (0.7% of the cases).

Whalen et al. [28] examined a sample of 30 youths with MDD compared to a control group of 23 youths. They evaluated caffeine use, sleep, and affect in their real environment using an EMA protocol. Participants received calls from staff members throughout an 8-week treatment protocol (a total of 60 calls in 8 weeks). Calls consisted of a brief interview with a subset of 5-point scales from the PANAS-C. During the last call of the day, patients were asked about caffeine consumption. They found that patients with depression used more caffeine than controls, which they related to the need to self-treat their symptoms of depression. They also demonstrated that caffeine use and sleep were not directly related. Participants using more caffeine reported more anxiety symptoms on the days they consumed caffeine. Although patients under treatment reported less caffeine use, sleep problems remained significant. No information about missing data or EMA adherence was published.

A cell phone EMA protocol was also used to determine co-rumination during social interactions among adolescents with MDD [27]. The authors examined a sample of 60 youths with a median age of 14.47 years. They demonstrated that adolescents with MDD present higher rates of co-rumination and fewer co-problem-solving strategies alongside peers compared to healthy controls. In this case, the EMA protocol consisted of a 3-week study of phone calls from staff. At least 50 participants answered 50% of the calls, and rates or participation did not differ depending on the existence of a mood disorder. EMA use permitted the evaluation of problem-solving, ruminative content, and determination of other social interactions as parents compared with self-questionnaire.

Primack et al. [23] conducted a study to determine the association between the type of media consumed (print media

use such as magazines, books, or tv/music/video games/ Internet) with symptoms of depression. The authors followed a sample of 106 participants, 46 of whom had been diagnosed with a mood disorder. The EMA protocol consisted of 8 weeks divided into five weekends, with a total of 60 telephone calls made by staff. They found that increasing audio use was associated with an 80% of having MDD. However, increasing print media use was associated with a 50% decrease of depression. Participants completed 88.6% of calls, and the completion rate was lower among youth with depression.

Forms/Diary With Digital Reminder

Bickham et al. [17••] conducted a study to determine the association between different media use and depressive symptoms in youth. They completed a 1-week EMA protocol the week following enrollment and 1 additional week to evaluate reliability. Patients carried a computer delivering four to seven signals per day at different times of the day. Participants had to respond to a questionnaire asking about their activities. They found that use of media such as mobile phones and TV was associated with symptoms of depression, while listening to music, computer use, and video game use were not related with depression. In terms of adherence, 99.2% of participants completed the EMA procedure and responded to 43.48 signals over the 2-week period.

Experience sampling method was used by Frost et al. [21] to study gender differences and depressive symptoms in patients with mood disorders. They recruited a sample of 353 adolescents aged 11–18 years who followed a 7-day ESM protocol, receiving 56 beeps a week prompting them to complete a mood and situation questionnaire. At every beep, patients were asked to complete a paper diary entry about what they were doing, their thoughts and feelings, and who they were with. Participants were asked to complete at least half of the diary entries in order to be included in the analysis. In this protocol, the authors measured negative and positive mood states and strong negative and positive emotions, including the reason of each strong emotion. The results indicated that females with more severe depressive symptoms were more likely to experience strong negative emotions compared to females without depression and to male participants. Both gender and depressive symptoms were independently related to emotional experiences and interacted in case of strong negative emotions. They remarked that the use of ESM allowed the evaluation of smaller stressful events that may not be captured in the retrospective self-report as more intense events, but may impact for gender differences in depression.

Vandeleur et al. [26••] conducted a study to determine familial aggregation of mood disorders. They followed 214 probands and their 389 offspring for a mean time of 11.9 years. For the evaluation, they used direct semi-structured diagnostic interviews, neurocognitive testing, anthropomorphic measures, biochemical exams, structural magnetic resonance imaging, and assessments of physical activity. They assessed circadian activity in participants older than 13 years using an accelerometer and EMA. This EMA protocol included an electronic diary where patients answered questions about emotions, stress, and sleep four times a day for a 1-week period. They found that offspring of parents with mood disorders presented higher rates of mood and anxiety disorders compared with the offspring of probands. Another finding was that information provided by offspring on themselves was a better predictor of psychopathology than parent reports.

In order to evaluate within-person co-occurrence of self-focus, negative affect, and stress in an adolescent community sample, Mor et al. [22] conducted a study including 278 adolescents interviewed about emotional disorders. They followed a 3-day protocol providing salivary samples six times a day and completing diary forms throughout the day where they were asked about current thoughts, level of stress, and affect. They demonstrated that momentary self-focus was associated with current negative affect, especially in patients with a recent diagnosis of depressive disorder compared to those with anxiety and comorbid depression and anxiety, or those without an emotional disorder.

Web Page/Mobile App EMA Protocol

Despite the large number of apps available, the evidence base is scarce, particularly for adolescents [30••]. Most mental health apps available for download are not supported by evidence-based research and may not follow evidence-based treatment guidelines.

We did not find any published articles on mood disorders and EMA that followed a protocol using a web page or mobile app to perform the measurements. We found three apps that focused on mood symptoms whose results were presented in workshops or conferences. Daybuilder [31] was created to assess mood symptoms, appetite, and sleep in patients with depression and help them to create events and reminders to prepare for those events. Mobile Mood Diary [32] was created to self-monitoring mood in young people following therapy. The ACT app also permitted self-monitoring, symptoms assessment, and skills training in patients attending therapy [33].

Discussion

The aim of this review was to examine the literature on EMA protocols for mental health in children and young people with mood disorders. Our review identified 11 papers and 4 works presented before conferences describing EMA usage via phone call, diaries with reminders, and mobile apps.

Usefulness Most of the studies reviewed demonstrated that the EMA protocol was useful in assessing affective symptoms in the moment and in patients' real-life environment. First, participants were able to report and rate their affect in the moment, which overcomes the recall bias. It is difficult for youth to remember feelings or sleep over the course of a week [34]. Furthermore, prior evidence has suggested an increase in negative memories among depressed adolescents mediated by a rumination induction compared with controls [25, 35]. Mokros et al. [7] demonstrated that adolescents with depression were not more likely to report sadness and irritability than controls in real time but were more likely to report these symptoms retrospectively. These findings explain why depressed adolescents may exaggerate mild negative events, amplifying this recall and generalizing to other experiences [36, 37]. When patients are interviewed by clinicians, their report is then conditioned by this affective distortion with a different representation of reality.

The EMA protocol has been used in a broad variety of studies regarding mood disorders in adolescents. It has been helpful to determine the association between the type of media use with symptoms of depression [17••, 23], predicting pharmacological treatment response in patients with depression and anxiety [20], and determining relationships between affect and sleep [18] or affect and caffeine consumption [28]. EMA also permitted the evaluation of problem-solving, ruminative content, and social interactions compared to self-reports in a sample of adolescents with depression [27]. As it has been used for self-monitoring over time, EMA has demonstrated usefulness for evaluating emotions and how they vary over time [27]. These findings lead to important clinical implications that may help to understand more reliably participants' daily emotional experiences, predicting and improving treatment response.

Finally, EMA has been used in the field of neuroscience. It has been helpful to find functioning brain differences related to subjective positive affect in patients with major depressive disorder [19] and links between pupil reactivity to emotional stimuli and major depressive disorder [24].

Feasibility For feasibility outcomes of EMA usage, one of the main problems of longitudinal studies is the low rate of patient attendance. Multiple reminders are needed and data are frequently lost. Using an EMA protocol, patients were able to report their affect in their real environment, thereby improving completion rates. Regarding phone EMA protocol, data were missing from 5% [19] to 11.5% of the calls [20]. These findings are consistent with adherence results obtained in other works [38–40]. In terms of completion rates, no differences were found between EMA phone protocol and diaries used with a digital reminder [17••].

One of the limitations of the studies that we reviewed was that EMA analysis included average rates of items

throughout the day [18], with no distinction made between morning, afternoon, and night, which could be beneficial to isolate factors such as sleep or mood throughout different times of the day. Additionally, these studies do not specify periods with higher rates of completion (first weeks vs last weeks of the study) or average phone calls responded per day or each weekend.

Previous works have suggested that mood self-monitoring via apps permitted better adherence compared to paper self-monitoring [40, 41]. EMA allows a higher level of engagement with media compared to other resources such as time use diaries (TUD) or summary questions [17••].

Acceptability/Satisfaction Rates The sample sizes in the majority of studies were small, but overall, EMA acceptability was good if we consider the high completion/adherence rates obtained [19, 20]. As none of the studies that we reviewed reported satisfaction rates, they cannot be compared with other works using EMA or other apps. The articles included in this review do not include either qualitative feedback from participants as to whether they consider the method was helpful, easy to use, if they would recommend an EMA protocol-based intervention to other youth, or privacy concerns. In other studies, satisfaction was reasonably good [30••, 41]. In a study using the app "CopeSmart" developed for self-monitoring and promotion of positive strategies among adolescents, it was demonstrated that 70% of participants stated that they would use the app again and would recommend it to a friend [38]. However, EMA acceptability may depend on the characteristics of the sample. In a study conducted by Moitra et al. [42], participants with psychotic spectrum disorders used an EMA app. They reported some barriers to EMA use, including duration of the study period, lack of feedback for users, technical problems, user displeasure with the smartphone, and displeasure caused by the need to carry a separate device.

Apps may be useful for adolescents, who may accept new technologies better than other face-to-face approaches, improving engagement and reducing concerns about stigma [43, 44]. In some cases, they may be less reluctant to report their emotional experiences using an electronic device than with live interviewers.

Insight EMA use when conducting repeated assessments of mood symptoms, companions, and daily events may improve patients' insight. Patients are more aware of the correlates of their symptoms so they are able to introduce changes in their daily routines [45]. However, the continued assessment conducted via EMA may also contribute to symptom rumination, impeding normalized functioning. Depending on the methodology of the study, participants receive multiple calls or reminders throughout the day to collect information on their feelings or activities at the moment [18, 19, 24]. When this

happens, patients have to stop their activity and complete the assessment via phone or by scoring different variables on scales or responding to questions on a website after receiving a reminder.

Limitations of EMA Studies EMA studies also have important limitations. As we did not find any studies with participants under age 7, we can conclude that there is no evidence to support the effectiveness of EMA for young children with mood disorders. This is consistent with the underlying attributes of the EMA methodology: participants should be able to read and have a minimum level of autonomy in order to provide objective responses and with no help from parents, as this would limit reliability and privacy. As EMA procedures can lead to some difficulties, either participants or parents should undergo specific training before starting the study, especially if apps/web or self-report via diaries or forms are used [17••, 21].

EMA techniques may be used to collect a significant amount of data, which can make these studies more expensive and difficult to conduct [46]. Multiple factors are evaluated and collected over time, so EMA statistical analysis can be a limitation for researchers not familiar with EMA procedures [46].

Participants' culture and economic status are relevant factors affecting the use of EMA protocols, especially when using apps or diaries. These individuals may not have Internet access or education in the use of telecommunications, which may impede the participation and bias the results [47].

Limitiations of our review Our review has several limitations. First, the number of studies regarding EMA and mood disorders in adolescents was small, so the conclusions reached are tentative and should not be systematically generalized. Second, we did not include EMA studies in adults, which may have highlighted some of the limitations of the reviewed articles. We also did not include other works evaluating mood states without a mood disorder diagnosis that may lead to data about rates of compliance, feedback from patients, or utility. Third, we did not find studies on populations under 7 years of age, so the results should not be generalized to this population. Fourth, our search was limited to English-language papers. Fifth, the number of papers using an EMA protocol via phone call is consistently higher than those using apps or diaries. EMA approaches based on phone calls, apps, and diaries are methodologically different, so their results should be interpreted accordingly.

Ethics Debates

Finally, ethics debates regarding EMA are ongoing. Clinicians must be ensure that patients will benefit from the use of the protocol, obtain informed consent, discuss confidentiality and benefits/risks, and adhere to the established goals and expectations [48].

Conclusions

This review demonstrates that EMA is feasible and useful for the evaluation of mood disorders in adolescents, evaluating mood changes over time with relevant clinical implications. Overall, acceptability and compliance rates were high, although feedback from patients was not evaluated. It is necessary to conduct more research in order to compare and generalize our results.

Compliance with Ethical Standards

Conflict of Interest   The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent   This article does not contain any studies with human or animal subjects performed by any of the authors.

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