



Research Paper

Electrodermal activity moderates the relationship between depression and suicidal ideation in a group of patients with anxiety and depressive symptoms

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ABSTRACT

Purpose: Being suicide a serious global issue, it's urgent to identify the involved factors and possibly precursors. In our study, it was hypothesized that autonomic hyperactivation might have a moderating role in the relationship between symptoms of depression and suicidal ideation in a group of patients suffering from Mixed Anxiety Depressive Disorder (MADD).

Methods: Fifty-three outpatients diagnosed with MADD were consecutively recruited. Anxiety and depression levels were assessed through the Symptom Questionnaire whereas suicidal ideation was calculated through specific items extrapolated from the Symptom Checklist-90-R (SCL-90-R). Additionally, Electrodermal Activity (EDA) and the evaluation of Skin Conductance, Level and Response (SCL-SCR), was detected through the recording of a Psychophysiological Stress Profile (PSP).

Results: The analyses confirmed depression as the first predictor of suicidal thoughts. Nonetheless, EDA levels recorded at baseline and under induced stress exerted a moderating effect on the relationship between thymic deflection and thoughts of death.

Conclusions: Even though activation is usually considered a positive factor for clinical prognosis, our findings highlight that autonomic arousal may represent a harmful resource for patients suffering from MADD. The involvement of the psychophysiological axis can accentuate mental suffering and favor suicidal ideation. The need to consider a multidimensional assessment strongly emerged.

1. Introduction

Suicide is among the leading causes of death worldwide, more than malaria, HIV/AIDS, breast cancer, war, and homicide. Globally, 703,000 people die by suicide every year (World Health Organization report, 2019). In Italy, about 4000 young people take their own lives every year (Terranova, 2022). Nevertheless, the aggregate annual incidence rate of suicides in the first year of the pandemic tragically augmented (4.9 cases/100,000, +10 % compared to 2019) (Bersia et al., 2022). In light of these considerations, suicide is increasingly proving a serious global public health issue and the World Health Organization (WHO) is constantly prioritizing its reduction as a global target (2019). Suicidal ideation is the risk factor most frequently associated with suicidal attempts (Berman et al., 2014). Although suicidal ideation does not always turn into anti-conservative behaviors, it is still deemed an alarming

symptom (Chin and Holden, 2013). The exacerbation of this mental attitude is well known with the constructs of "hopelessness" (Beck et al., 1974) or "psychache" (Shneidman, 1993), which are both frequently associated with severe depressive disorders (Lambert et al., 2020). More generally, suicide occurs in individuals who have at least one mental disorder in 95 % of cases (American Psychiatric Association, 2022).

These data are even more alarming considering that the Covid-19 pandemic has dramatically exacerbated experiences of mental distress, increasing the prevalence of mental disorders such as anxiety and depression (Bueno-Notivol et al., 2021; Lima et al., 2020; Rajkumar, 2020).

Depressive and anxiety disorders are the most frequently diagnosed psychiatric categories (Bandelow and Michaelis, 2015). About 280 million people in the world suffer from depression and 301 million suffer from anxiety, with a prevalence in the entire population of 4.4 % and

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3.6 % respectively (WHO, 2019). In addition, 85 % of depressed patients presented anxiety symptoms (i.e., vigilance, panic attacks, free or somatized anxiety, and phobias) whereas 90 % percent of individuals with anxiety disorder have comorbid depressive symptoms or major depressive disorders (Tiller, 2013). Moreover, the anxiety disorder usually precedes the depressive episode which, in turn, may further complicate anxiety (Cosci and Fava, 2021). The latest versions of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013; DSM-5-TR; APA, 2022) highlighted the importance of considering the comorbid anxious activation within depressive disorders because it is associated with a greater risk of suicide. The latest revisions of the diagnostic manuals offer their support including new diagnostic criteria for the Mixed Anxiety Depressive Disorder (MADD). However, it is often difficult for clinicians to diagnose the anxious-depressive syndrome correctly.

For this purpose, the investigation techniques deriving from clinical psychophysiology can be very useful because specific biological abnormalities may be risk factors for severe psychopathological symptoms (Sudol and Mann, 2017). The use of autonomic responses as markers of specific emotional and cognitive processing (i.e., emotion, attention, decision-making, etc.) has been a growing field since the 1980s (Öhman et al., 2000). Among the most useful indicators of the state of the autonomic nervous system (ANS), is the Electrodermal Activity (EDA), in which its activity is under sympathetic control (Sarchiapone et al., 2018). The EDA parameter corresponds to the changes in the electrical conductance of the skin, which depend on the quantity of sweat secreted by eccrine sweat glands in the hypodermis of the palmar and plantar regions (Groscurth, 2002). Sympathetic nervous activity and the EDA recording are influenced not only by thermoregulatory sweating but also by affective and cognitive states (Asahina et al., 2003; Gunn et al., 2011). EDA is used as a good index of emotional arousal because it has a tonic and a phasic component. The tonic component is related to the slower components and background characteristics of the signal (Skin Conductance Level; SCL) whereas the phasic component is the faster-changing element of the signal that can be associated with a stimulus (Skin Conductance Response; SCR) (Pruneti et al., 2023). The exposition of emotional stimuli provokes the amplitude of electrodermal response that is linearly associated with perceived arousal (Sarchiapone et al., 2018). Considering the most widespread psychological symptoms of distress, both depression and anxiety have been extensively investigated from a physiological point of view. The extant research attested that depressed and suicidal patients showed electrodermal hypo-activity (Sarchiapone et al., 2018) whereas anxiety disorders are usually characterized by autonomic hyper-activation (Pruneti et al., 2010, 2014, 2016a).

In light of these assumptions, our work aims to describe the complexity of the suffering of people with both depressive and anxious symptoms. In particular, the analysis of distress on a subjective and objective level should highlight any concordant or discordant indices concerning suicidal risk. Therefore, the present study aimed to (1) confirm the predicting role of depression in suicidal ideation in a group of patients with MADD; (2) investigate whether skin conductance could predict or have a moderator effect on the relationship between depression and suicidal ideation.

2. Materials and methods

2.1. Participants and procedure

This cross-sectional study enrolled 53 consecutive persons visiting the outpatient clinic of the Clinical Psychology, Clinical Psychophysiology, and Clinical Neuropsychology Laboratories of the University of Parma between April 2022 and May 2023. The MADD diagnosis was established by assessing the patients with the Structured Clinical Interview for DSM-5 Disorders (First et al., 2017). Criteria for inclusion in the study were age > 18 years old; completion of informed consent; no

history of psychiatric and/or neurological syndromes (e.g. previous head trauma, epilepsy, etc.) and/or physical diseases (i.e., sensory disturbances of sight and/or hearing) that may limit the administration of the tests; no assumption of psychotropic drugs with rebound effects on the ANS in the last three months (i.e., tricyclic antidepressants, anti-psychotics, norepinephrine-dopamine reuptake inhibitors such as bupropion, serotonin modulators such as mirtazapine and trazodone, serotonin-norepinephrine reuptake inhibitors such as venlafaxine and duloxetine, etc.).

2.2. Measures

The symptoms of depression and anxiety were assessed through the *Symptom Questionnaire* (SQ; Kellner, 1976; Fava et al., 1983). This instrument investigates the presence of psychopathological symptoms including Anxiety (A), Depression (D), Somatization (S), and Hostility (H). Each of the main scales includes items from both the symptoms and the well-being sub-scales. The clinical cut-off corresponds to 4 for all the scales of the test. The SQ was shown to have high sensitivity and specificity levels (80 % and 76 % in general practice, respectively; 86 % and 74 % in hospital medical wards; and 83 % and 85 % in emergency departments (Rucci et al., 1994). This test has weekly, daily, and hourly versions. For this research, the weekly version was used.

Specific items derived from the *Symptom Checklist-90-Revised* (SCL-90-R; Derogatis, 1994; Prunas et al., 2012) were used to measure suicidal ideation. The SCL-90-R is a self-report instrument measuring psychopathological symptoms including Somatization (SOM), Obsessive and Compulsive (O-C), Interpersonal sensitivity (I-S), Depression (DEP), Anxiety (ANX), Hostility (HOS), Phobic anxiety (PHOB), Paranoid ideation (PAR), and Psychoticism (PSY) (cut-off=0.75). The items are rated on a five-point Likert scale of distress in the previous week: “not at all” (0), “a little bit” (1), “moderately” (2), to “quite a lot” (3), and “extremely often” (4). There are two items of SCL-90-R asking about suicidal thoughts (i.e. items 15 “In the previous week, how much were you distressed by thoughts of ending your life?” and 59 “In the previous week, how much were you distressed by thoughts of death or dying?”). Suicidal ideation was measured by summing the scores of these items simultaneously. Measurement of suicidal ideation based on the SCL-90-R items has been successfully used in previous studies and has been confirmed to be significantly related to suicide attempts (Meng et al., 2013).

A *Psychophysiological Stress Profile* (PSP; Fuller, 1979) was examined using the ProComp Infiniti System (Thought Technology Ltd., Montreal) connected to a computer. All of the following indices were measured: surface electromyography (sEMG), galvanic skin response (GSR) or EDA, blood volume pulse (BVP), and respiratory rate and amplitude (RESP). Among these indices, analysis was performed using only GSR (or EDA). The GSR was continuously registered where a very low-intensity electrical direct current was attained employing two electrodes placed on the first and second fingers of the non-dominant hand. Two 1 cm² circular silver-plated electrodes were employed. The participants were seated in a chair with their eyes closed during the measurements. The room temperature was kept at 19–21 °C. After a 2-min preparation period, the assessment was performed in the following steps (5 min each, a total of 15 min): (1) in the baseline phase, each patient was instructed to close their eyes and to remain still and relaxed; (2) in the stress phase, a Mental Arithmetic Task (MAT) was presented to the participant. This task consists of subtracting the number 13 from the number 1007 and continuing to subtract 13 from each successive result that was obtained; (3) lastly, in the recovery phase, the patient was instructed to relax again. In a relaxed state, the GSR value of healthy subjects is around 2 μS and increases from 0.1 to 1 μS under induced stress (Cacioppo et al., 2010).

2.3. Statistical analysis

All of the statistical analyses were performed using SPSS (Version 28.0.1.0; IBM Corp, Armonk, NY, USA). Descriptive statistics were performed with the calculation of the mean (M) and standard deviation (SD) and the differences between males and females were computed with an Independent Sample T Test. A Pearson's correlation analysis was conducted to examine the association between the psychological and physiological dimensions of interest (i.e., anxiety, depression, suicidal ideation, and skin conductance). Tests for skewness, kurtosis, and Kolmogorov-Smirnov were used to determine the normality of distribution. Furthermore, in a multicollinearity test, no extreme coefficient values ≥ 0.8 were found among the independent variables, indicating a low risk of multicollinearity. All independent variables had variance inflation factors ≤ 10 and tolerance ≥ 0.1 , indicating the absence of multicollinearity. Thus, all the assumptions for the conduction of parametric statistics have been respected. Preliminarily, a linear regression was implemented considering depression, skin conductance at baseline, and skin conductance under stress as predictors and suicidal ideation as dependent variables. To test our hypothesis, in the moderator model, depression (SQ Depression) was the independent variable, suicidal ideation (SCL-90-R Suicidal ideation) was the dependent variable, and skin conductance (PSP Skin Conductance) was computed as the moderator variable. Two moderator models were computed assessing the moderator effect of skin conductance recorded at baseline and under induced stress one at a time.

3. Results

3.1. Descriptive statistics and correlations between the variables of interest

The sample was composed of 15 (28.3 %) males and 38 (71.7 %) females. The mean age was 27.34 (SD=10.26). Most of the participants were single (83 %) (17 % were married or cohabitant), students (79.2 %) (20.8 % were employed), and had a high school diploma (54.7 %) (43.4 % had a university degree and only one people had a middle school diploma). As concern the diagnosis, 29 (54.7 %) people were diagnosed with Major Depressive Disorder (MDD) and 24 people (45.3 %) had Dysthymic Disorder (DD). All of the patients also met the criteria for the "with anxiety" specifier, in agreement with the DSM-5-TR. Descriptive statistics are shown in Table 1.

For the entire sample, the symptoms of anxiety and depression exceeded the cut-off of the SQ. Looking at the EDA, the mean values of the entire sample during the baseline phase of the PSP are close to the expected value (about 2 μ S). However, a modest reactivity under stress (the difference between baseline and stress is greater than 1 μ S) can be observed as well as an incomplete recovery of the baseline values in the recovery phase. No differences between males and females emerged for any of the variables of interest (Table 1).

Looking at the correlations, anxiety, and depression were significantly associated between them. Moreover, altered mood was

significantly associated with suicidal ideation measured with the two items of the SCL-90-R. Thoughts of death were, in turn, significantly associated with the EDA values recorded both at baseline and under induced stress. The three values of EDA of the three phases of the PSP were correlated with each other (Table 2).

3.2. The moderation models

Hierarchical linear regression was performed to investigate the significance of depression and EDA as predictors of suicidal ideation. The analysis found that the only significant predictor was depression (Table 3).

The moderation models are presented in Figs. 1 and 2. In a first moderation model, it was hypothesized whether Skin Conductance (recorded at baseline) could have a significant moderator effect on the relationship between Depression and Suicidal Ideation. Our analyses revealed that Depression was a significant predictor of Suicidal Ideation [$B = 0.27$; $SE = 0.05$; $p < 0.001$; LLCI-ULCI (0.17, 0.37)], explaining 37 % of the variance ($F(1, 51) = 31.61$; $p < 0.001$). Additionally, the baseline value of the Skin Conductance [$B = 0.92$; $SE = 0.20$; $p < 0.001$; LLCI-ULCI (0.51, 1.33)] exerted a significant moderation effect on the relationship between Depression and Suicidal Ideation, explaining 19.1 % more of the variance than linear regression alone ($F(2, 50) = 31.97$; $p < 0.001$). The final model including gender (coded as 1=females and 0 = males) [$B = -0.76$; $SE = 0.44$; $p = n.s.$; LLCI-ULCI (-1.64, 0.13)] and age [$B = -0.01$; $SE = 0.02$; $p = n.s.$; LLCI-ULCI (-0.04, 0.04)] as covariates explained 58.87 % of the variance ($F(5, 47) = 13.45$; $p < 0.001$).

In the second moderation model, the moderator effect of Skin Conductance (recorded during the stress phase) on the relationship between Depression and Suicidal Ideation was investigated. Skin Conductance value recorded under induced stress [$B = 0.41$; $SE = 0.20$; $p < 0.05$; LLCI-ULCI (0.01, 0.81)] exerted a significant moderator effect on the predicting role of Depression on Suicidal Ideation [$B = 0.27$; $SE = 0.05$; $p < 0.001$; LLCI-ULCI (0.17, 0.37)], explaining the 6 % of variance more ($F(2, 50) = 18.96$; $p < 0.001$). Gender (coded as

Table 2
Relationship between variables and descriptive analyses of the sample ($n = 53$).

	1	2	3	4	5
1 SQ Anxiety	–				
2 SQ Depression	.69**				
3 SCL-90-R Suicidal ideation	–	.62**			
4 PSP Electrodermal Activity (baseline)	–	–	.32		
			*		
5 PSP Electrodermal Activity (stress)	–	–	.28	.74**	
			*		
6 PSP Electrodermal Activity (recovery)	–	–	–	.75**	.98**

Legend: PSP, Psychophysiological Stress Profile; SCL-90-R, Symptom Checklist-90-Revised; SQ, Symptom Questionnaire;

** $p < 0.01$;

* $p < 0.05$.

Table 1

Comparisons of psychological and psychophysiological variables between male and female (total=53).

Clinical features	Male ($n = 15$)		Female ($n = 38$)		Total sample ($n = 53$)		$t(51)$	p
	M	SD	M	SD	M	SD		
Symptom Questionnaire								
Anxiety	9.33	4.95	11.00	4.62	10.53	4.73	-1.16	n.s.
Depression	10.33	5.75	9.68	4.26	9.87	4.68	0.45	n.s.
Suicidal Ideation								
SCL-90-R items	1.33	2.44	0.71	1.86	0.89	2.03	1.00	n.s.
Electrodermal Activity								
Baseline	2.14	1.01	2.88	2.35	2.69	1.12	-1.16	n.s.
Stress	4.90	3.20	4.34	2.94	4.55	3.03	0.61	n.s.
Recovery	4.56	3.11	3.90	2.65	4.16	2.80	0.76	n.s.

Table 3
Hierarchical linear multiple regression analyses: predictors of Suicidal Ideation (Total score).

Model	Predictors	<i>b</i>	SE	β	<i>t</i> -test	<i>p</i>
SQ Depression		0.25	0.05	0.58	5.25	<0.001
PSP Electrodermal Activity (baseline)		0.22	0.16	0.23	1.41	n.s.
PSP Electrodermal Activity (stress)		-0.01	0.11	-0.02	-1.11	n.s.
$R^2 = 0.39^{***}$						

Note: All predictor variables are mean-centered.

Legend:

b, unstandardized regression coefficient; SE, standard error; β , standardized regression coefficient; PSP, Psychophysiological Stress Profile; SQ, Symptom Questionnaire.

*** $p < 0.001$.

1=females and 0 = males) [$B = -0.32$; $SE = 0.51$; $p = n.s.$; LLCI-ULCI (-1.36, 0.71)] and age [$B = -0.01$; $SE = 0.02$; $p = n.s.$; LLCI-ULCI (-0.04, 0.05)] were not significant predictors included as covariates. The final model explained 44.75 % of the variance ($F(5, 47) = 7.55$; $p < 0.001$).

4. Discussion

Obtained data seem to confirm previous studies on the high incidence of distress due to the COVID-19 pandemic (Bueno-Notivol et al., 2021; Guidotti et al., 2022). Anxiety and depression are among the most experienced psychological symptoms in the general population (Bandelow and Michaelis, 2015). Furthermore, anxious arousal accompanied by thymic deflection is a transversal condition in many mental disorders or situational psychological distress (Tiller, 2013). The coexistence of anxious and depressive symptoms in a group of subjects complaining of psychological distress has a very high prevalence (Cosci and Fava, 2021). In 2008, Kessler et al., had already found that the anxiety

disorders preceded the depressive episode with onset one to ten years earlier (i.e., 17.6 % Social Phobia, 7.8 % Specific Phobia, 6.7 % Generalized Anxiety, and 3.1 % Panic Disorder) and that they were the strongest predictor of a secondary depressive disorder.

Unlike the previous versions that forced the allocation of the patient in the category of anxious or depressive disorders, the DSM-5 (APA, 2013) and the DSM-5-TR (APA, 2022) allow the description of this mental condition in its complexity. The clinician can add the specifier "with anxiety" (also indicating the severity of activation from mild, moderate, moderate-severe, to severe) to the diagnosis of depressive disorder formulated. In the latest International Statistical Classification of Diseases and Related Health Problems (ICD-10; WHO, 2004), this condition is connoted by the term "mixed anxiety-depressive disorder" (MADD) (F41.2). Our interest in defining the relationship between depression and suicidal ideation within a group of MADD patients arose precisely from the suggestions provided by the most recent diagnostic manuals. In particular, the DSM-5-TR (APA, 2022) highlighted the importance of considering anxious activation in comorbidity with depressive disorders because it is associated with a longer duration of the disease and the likelihood of non-response to treatment as well as a greater risk of suicide.

As for the thoughts of death, their rate was not assessed directly in our sample. Suicidal ideation was calculated considering some items of the SCL-90-R in agreement with previous works (Meng et al., 2013). Consistent with the literature (APA 2013, 2022; Lambert et al., 2020; Schepis et al., 2021; Shneidman, 1993), the strongest association observed between the scores derived from this analysis was with depressive symptoms.

Our work wanted to include some biological measures to investigate whether the assessment of the state of autonomic activation might affect suicidal ideation along with depression. Looking at the skin conductance in the three phases of the psychophysiological evaluation, the values did not show a marked basic autonomic hyperactivation in our sample. The values were within the typical range of 2–4 μS (Cacioppo et al., 2010). However, some interesting considerations emerged when looking at the reactivity, which corresponds to the difference between the baseline and

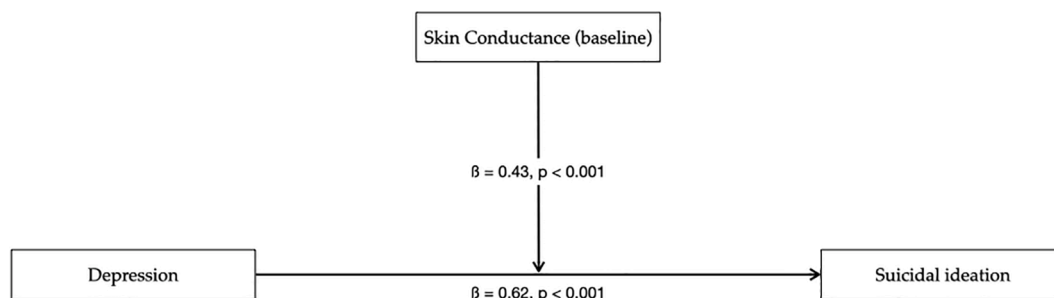


Fig. 1. The Skin Conductance recorded at baseline moderated the relationship between Depression and Suicidal Ideation (β , p). Standardized coefficients are reported.

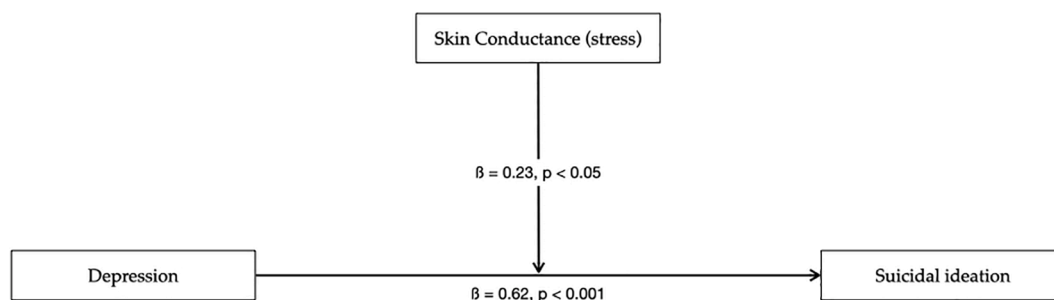


Fig. 2. The moderating role of Skin Conductance during the stress phase in the relationship between Depression and Suicidal Ideation (β , p). Standardized coefficients are reported.

the induced stress phase. In our sample, however, the value underwent a massive increase ($>1 \mu\text{S}$) to indicate a modest psychophysiological reactivity ascribable to anxious hyper-activation (Pruneti et al., 2010). Similarly, only a slight reduction in skin conductance was observed in the recovery phase. In agreement with the literature, this aspect is consistent with the marked reactivity to stressful stimuli and indicative of poor emotional self-management skills (Pruneti et al., 2014, 2016b).

Some authors also described an autonomic hyperarousal at rest and a marker reactivity to stressful conditions (i.e., arithmetic task or presentation of video images or sounds eliciting negative emotions) within the depressive syndromes (Byrne, 1975; Falkenberg et al., 2012; Lapiere and Butter, 1980; Levinson, 1991; Lewinsohn et al., 1973; Noble and Lader, 1971). Historically, however, depressive disorders were associated with autonomic hypoactivity at rest (Bonnet, and Naveteur, 2004; Breyer-Pfaff et al., 1982; Carney et al., 1981; Donat and McCollough, 1983; Perez-Reyes and Cochrane, 1967) and poor responsiveness at stress (Bonnet et al., 2004; Giedke and Heimann, 1987; Iacono et al., 1983; Miquel et al., 1999; Storrie et al., 1981). Also considering suicidal ideation, the literature underlined divergent findings among different authors. By way of illustration, Fraguas et al. (2007) did not confirm the negative correlation between thoughts of death and EDA values whereas other researchers reported the hypoactivity and hypo-reactivity configuration as a discriminant factor for suicide (Sarchiapone et al., 2018; Wolfersdorf et al., 1996). The positive correlation that emerged from our analyses, on the other hand, failed to substantiate the existing research in the literature.

In light of these considerations, we have deemed it useful to evaluate the interaction of all the variables involved in the suffering generated by the co-presence of symptoms attributable to the anxious-depressive syndrome. Instead of creating a group of patients highlighting only the presence of anxious or depressive symptoms, we wanted to contribute to clarifying the complex condition characterized by both psychopathological tendencies. Thus, two moderation models were performed to verify the research hypotheses. The analyses conducted confirmed depression as a good predictor of suicidal ideation (Lambert et al., 2020), and using two different psychometric tests. On top of this, autonomic hyperarousal influenced this relationship. In other words, higher EDA levels in baseline and under induced-stress can accentuate the appearance of suicidal thoughts induced by depression. Both the moderation models were able to explain a significant portion of the variance considering both the baseline EDA value and the stress condition (58.87 % and 44.75 %, respectively). Following Wilder's law of initial values (1958), it should be noted that both the models reached statistical significance despite the EDA value recorded during the stress phase may be affected by the baseline ones.

In summary, the coexistence of anxious and depressive symptoms can represent a clinical condition of psychological suffering. Furthermore, anxious activation can alter the psychophysical balance of patients diagnosed with MADD favoring a greater reactivity to stress with as many difficulties in managing negative emotionality and adapting to environmental demands. Consequently, both the symptomatologic dimensions may have an impact on the emotional-psychophysiological balance (Byrne, 1975; Falkenberg et al., 2012; Lapiere and Butter, 1980; Levinson, 1991; Lewinsohn et al., 1973; Noble and Lader, 1971), which, in turn, may affect the appearance of thoughts of death by accentuating intolerance towards low mood.

In the clinical context, the presence of anxious tension within depressive syndromes is a good indicator of the motivation for change connected to mental suffering (Sirigatti and Stefanile, 2001). Conversely, conditions characterized by autonomic hypoactivity aggravate the intensity of depressive symptoms and, also, are associated with worse prognosis and treatment adherence (Mori et al., 2016). The motivation for change and the change itself require lots of psychophysical energies that can be channeled by the clinician (Sirigatti and Stefanile, 2001). However, our work has highlighted the possible danger of a condition of psychophysiological activation in the case of patients

with anxious depressive symptomatology because it may accentuate suicidal ideation favored by depressive symptoms.

Despite the complexity of the interaction between the investigated variables, the use of clinical tools valuable for highlighting critical issues needs to be implemented. To illustrate, a brief clinical interview aimed at investigating the person's history and identifying any stressful life events or a previous history of mental disorder could provide crucial information. Consequently, personal stress reactivity has to be assessed using standardized psychometric tests but also supported by an adequate psychophysiological assessment. The execution of a psychophysiological stress profile fully satisfies the cost-benefit analyses that generally must be respected within public and private clinical psychology units. Even requiring specialized personnel for the execution and analysis of the data performed (usually they are psychologists who are experts in clinical psychophysiology and biofeedback), the equipment and software are low-cost and the procedure is entirely non-invasive.

The present study is not without limitations. First of all, the cross-sectional nature of the study cannot confirm the causality of relationships between observed variables. It could be useful to replicate the methods and procedure in groups of patients who are in psychiatric units in which anxious and depressive symptoms, as well as suicidal ideation, induce higher levels of risk. Furthermore, future studies could repeat the same analyses in a group of patients whose clinical history reports suicidal attempts, not just ideation. It could also be useful to better balance the sample because in our group the females were in the majority. However, even though anxiety and depression are more frequent in the female gender (Pérez-Cano et al., 2020) while EDA values are generally lower (Ward et al., 1983), this trend was not confirmed in our sample. Another limitation concerns the lack of standardized instruments for assessing suicidal ideation. Despite the measurement of suicidal ideation based on the SCL-90-R items having been successfully used in previous studies and being confirmed to be significantly related to suicide attempts (Meng et al., 2013), explicit questions about suicidal ideation might not accurately reflect suicidality. Questions designed specifically to assess suicidal thoughts with face validity may be more appropriate.

Despite these limitations, other noteworthy aspects shed light on clinical implications, because our findings underlined that psychophysiological arousal can assume the role of moderator within relationships between psychological variables. So, these results could be useful in the treatment, both pharmacological and psychotherapeutic. For instance, the results we have described could better explain the phenomenon of activation in which the administration of a stimulant drug (i.e., antidepressants) to a depressed patient can sometimes accentuate suicidal ideation and support attempts (Pruneti et al., 2016a; Pruneti and Guidotti, 2023; Tulisliak et al., 2017).

5. Conclusion

To conclude, our work highlighted the interaction between subjective (explicit) and objective (implicit and less influenced by social desirability) variables by better describing mental suffering in its complexity. At last but not at least, our findings provide evidence that mental distress, along with emotional arousal, might promote the production of suicidal thoughts. The relationship between depression and suicidal ideation seems to be moderated by psychophysiological arousal. The complexity of mental distress has been described but highlighted findings partially divergent from the literature. The fact that ANS hyperarousal is generally associated with anxiety, whereas ANS hypoarousal is associated with depression, needs clarification in the conditions in which the two symptoms are co-present. Our work found that increased arousal could accentuate the thoughts of death associated with depression in a group of MADD patients. At the clinical level, these data have a significant impact because activation, within certain limits, can be a good indicator of treatment adherence and prognosis. However, our results highlight a clinical condition that could be dangerous provoking, in the most severe cases, the so-called "acting-outs".

Multidisciplinary screening programs may favor the danger of suicidal detection by identifying the risk factors that anticipate and moderate suicidal thoughts. A multidimensional clinical psychological and psychophysiological assessment can represent a valid contribution to identifying the implicit and explicit factors that modulate mental suffering.

Data availability statement

The data presented in this study are available upon reasonable request from the corresponding author.

Funding statement

This research received no external funding.

Ethical approval statement

The Ethical Committee of the University of Parma approved the study (protocol number: 254676/2023). All procedures were conducted following the Declaration of Helsinki and its later advancements.

Patient consent statement

All data were handled in accordance with the ethical standards established in the 1964 Helsinki Declaration. Subjects' anonymity was preserved, and the data obtained were used solely for scientific purposes. All patient/personal identifiers have been removed or disguised so the patient/person(s) described are not identifiable and cannot be identified through the story's details.

CRedit authorship contribution statement

Carlo Pruneti: Conceptualization, Writing – review & editing. **Alice Fiduccia:** Data curation, Writing – original draft. **Sara Guidotti:** Methodology, Data curation, Formal analysis, Writing – original draft.

Declaration of Competing Interest

The authors declare no conflict of interest.

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