

*Original research articles based on limited empirical data*

# Relationship Between Internalizing Symptoms and Resting Heart Rate Variability

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### Abstract

The dimensional approach to psychopathology enables the identification of traits and symptoms involved in the onset or maintenance of various mental disorders. Within this framework, new categorizations have emerged, such as the distinction between internalizing and externalizing symptoms. Furthermore, dimensional models provide a closer alignment with biomarkers. A potential transdiagnostic biomarker for psychopathologies is heart rate variability (HRV). Given the evidence of HRV alterations across different mental disorders, the aim of this study was to assess the relationship between resting-state HRV levels (using the RMSSD parameter) and internalizing symptoms (anxiety, depression, and stress) as measured by the DASS-21 (Depression, Anxiety, and Stress Scale). The total sample consisted of 60 individuals aged 18 to 40 ( $M = 28.53$ ;  $SD = 5.85$ ), with 50.0% ( $n = 30$ ) reporting a self-diagnosis of mental health disorders. Spearman correlations were performed to assess the association between DASS-21 scores and HRV. In the total sample, the results indicated significant negative correlations between HRV and all DASS-21 subscales. When divided by groups, HRV showed a significant correlation with the mental disorder group in the Total, Depression, and Stress scores of the DASS-21. No significant correlations were found in the control group. These results suggest that the intensity of internalizing symptoms is associated with HRV, supporting a dimensional perspective.

**Keywords:** heart rate variability, psychophysiology, anxiety, depression, stress

## RELAÇÃO ENTRE SINTOMAS INTERNALIZANTES E VARIABILIDADE DA FREQUÊNCIA CARDÍACA EM REPOUSO

### Sintomas Internalizantes e Variabilidade da Frequência Cardíaca

#### Resumo

A abordagem dimensional de psicopatologia permite a identificação de traços e sintomas presentes na origem ou na manutenção de diversos transtornos mentais. Diante dessa lógica surgem novos agrupamentos como, por exemplo, a divisão entre os sintomas internalizantes e externalizantes. Além disso, os modelos dimensionais possuem uma melhor aproximação com biomarcadores. Um potencial biomarcador transdiagnóstico das psicopatologias é a variabilidade da frequência cardíaca (VFC). Diante das evidências de alterações da VFC em diversas psicopatologias, o objetivo deste estudo foi avaliar a relação entre níveis de VFC em repouso (parâmetro RMSSD) com sintomas internalizantes (ansiedade, depressão e estresse) mensurados pela escala DASS-21 (Depression, Anxiety and Stress Scale). A amostra total desse estudo incluiu 60 indivíduos com idades entre 18 e 40 anos ( $M = 28,53$ ;  $DP = 5,85$ ), nessa amostra, 50,0% ( $n = 30$ ) participantes apresentavam autorrelato de diagnóstico em saúde mental. Foram realizadas correlações de Spearman para avaliar a associação entre a DASS-21 e a VFC. Na amostra total, os resultados indicaram que a VFC apresentou relações negativas e significativas com todas as variáveis de escore do DASS-21. Quando divididos por grupos, a VFC apresentou correlação significativa com o grupo com transtorno mental nos escores Total, Depressão e Estresse da DASS-21. No grupo controle não foram encontradas correlações significativas. Tais resultados indicam que a intensidade dos sintomas internalizantes está associada com VFC, corroborando com uma visão dimensional.

**Palavras-chave:** variabilidade da frequência cardíaca, psicofisiologia, ansiedade, depressão, estresse

## RELACIÓN ENTRE LOS SÍNTOMAS INTERNALIZANTES Y LA VARIABILIDAD DE LA FRECUENCIA CARDÍACA EN REPOSO

### Síntomas internalizantes y la variabilidad de la frecuencia cardíaca

#### Resumen

El enfoque dimensional de la psicopatología permite la identificación de rasgos y síntomas presentes en el origen o mantenimiento de diversos trastornos mentales. A partir de esta lógica, surgen nuevos agrupamientos, como, por ejemplo, la división entre los síntomas internalizantes y externalizantes. Además, los modelos dimensionales tienen una mejor correlación con biomarcadores. Un posible biomarcador transdiagnóstico de las psicopatologías es la variabilidad de la frecuencia cardíaca (VFC). Ante la evidencia de alteraciones de la VFC en diversas psicopatologías, el objetivo de este estudio fue evaluar la relación entre

los niveles de VFC en reposo (parámetro RMSSD) y los síntomas internalizantes (ansiedad, depresión y estrés) medidos mediante la escala DASS-21 (Depression, Anxiety and Stress Scale). La muestra total de este estudio incluyó a 60 individuos de entre 18 y 40 años ( $M = 28,53$ ;  $DE = 5,85$ ); de estos, el 50,0% ( $n = 30$ ) de los participantes presentaban autorreporte de diagnóstico en salud mental. Se realizaron correlaciones de Spearman para evaluar la asociación entre la DASS-21 y la VFC. En la muestra total, los resultados indicaron que la VFC presentó correlaciones negativas y significativas con todas las variables de los puntajes de la DASS-21. Al dividir la muestra por grupos, la VFC presentó una correlación significativa con el grupo con trastorno mental en los puntajes Total, Depresión y Estrés de la DASS-21. En el grupo control no se encontraron correlaciones significativas. Estos resultados indican que la intensidad de los síntomas internalizantes está asociada con la VFC, corroborando una perspectiva dimensional.

*Palabras clave:* variabilidad de la frecuencia cardíaca, psicofisiología, ansiedad, depresión, estrés

The study of mental disorders focuses on identifying symptom patterns with similar trajectories and associations with specific psychopathologies (Câmara, 2007). The Diagnostic and Statistical Manual of Mental Disorders (DSM) and the International Classification of Diseases (ICD) were developed to classify mental disorders. These classification systems adopt a predominantly categorical approach to psychopathology, offering a relevant framework for public health, facilitating clinical diagnosis, and supporting research (Clark et al., 2017).

Despite their contributions, categorizing psychopathology based solely on symptoms has been increasingly questioned, especially as research in the field advances (Jablensky, 2016). Some scholars argue that current classification systems are not keeping pace with scientific progress across disciplines (Casey et al., 2013). These critiques highlight the need to explore psychopathology from alternative perspectives, such as dimensional (Jablensky, 2016) and transdiagnostic approaches (Clark et al., 2017).

The dimensional perspective conceptualizes psychopathology as a continuum, ranging from typical functioning to clinical levels currently classified as mental disorders (Beauchaine & Thayer, 2015; Carvalho et al., 2023). This view facilitates the identification of both subclinical and clinical traits and symptoms involved in the onset or maintenance of mental illness (Caspi & Moffitt, 2018; Conway & Krueger, 2020; Kotov et al., 2017).

Transdiagnostic factors refer to common processes observed across different mental disorders (Barch, 2020; Fernandez et al., 2016), potentially playing a causal or maintenance role in these conditions (Harvey et al., 2004). These factors help explain the high comorbidity rates seen in current diagnostic categories, as symptom overlap is frequent among disorders classified as distinct (Clark et al., 2017; Kotov et al., 2018). For instance, disorders such as depression, anxiety, post-traumatic stress disorder (PTSD), and obsessive-compulsive disorder (OCD) are placed in separate diagnostic classes in the DSM-5-TR (APA, 2022), despite substantial similarities in several diagnostic criteria. This observation supports research that emphasizes two key dimensional constructs of mental illness: internalizing and externalizing symptoms. Some authors define internalizing symptoms as a “distress dimension” associated with mental anguish and emotional suffering, identifying it as a transdiagnostic factor (Kotov et al., 2022).

Accordingly, recent years have seen a growing number of studies seeking alternative ways to conceptualize psychopathology. These investigations aim to refine how mental disorders are studied and classified, providing evidence that supports dimensional and transdiagnostic frameworks of mental health (Insel et al., 2010; Kotov et al., 2017). Dimensional models grounded in multiple levels of analysis—including genetic, neural, psychophysiological, and behavioral—have emerged as viable alternatives (Beauchaine & Thayer, 2015; Cattaneo et al., 2021).

One of the tools commonly used to assess internalizing symptoms is the Depression, Anxiety, and Stress Scale – 21 Items (DASS-21) (Lovibond & Lovibond, 1995; Brazilian adaptation by Vignola, 2013). This instrument is used to assess the symptomatology and mental distress related to depression, anxiety, and stress, allowing these phenomena to be analyzed collectively rather than in isolation, which aligns with a dimensional perspective (Patiás et al., 2016). The

DASS-21 has been used to assess distress in a wide range of contexts, including outpatient cancer patients undergoing chemotherapy (McMullen et al., 2018), healthcare professionals during the COVID-19 pandemic (Alghamdi et al., 2022; Da Rosa et al., 2021; Petzold et al., 2020), postpartum women (Miller et al., 2006), adolescents (Evans et al., 2020), and individuals exposed to childhood adversity (Wolff & Caravaca, 2019), among others. Thus, the variables assessed by the DASS-21 not only serve as a screening tool for current disorders but also provide indications of internalizing symptomatology.

Moreover, dimensional models tend to show a stronger association with biomarkers of psychopathology (Cuthbert, 2020; Insel et al., 2010; Kotov et al., 2017). Research connecting mental disorders to physiological markers has existed since the last century (Beauchaine & Thayer, 2015). However, such studies gained prominence only with the rise of dimensional and transdiagnostic frameworks, since psychophysiological markers were traditionally considered nonspecific—that is, not tied to a particular disorder, but rather to physiological responses shared across multiple conditions (Beauchaine & Thayer, 2015). This paradigm began to shift with the development of initiatives such as the Research Domain Criteria (RDoC) and Hierarchical Taxonomy of Psychopathology (HiTOP), which advocate for the inclusion of transdiagnostic perspectives and biomarkers (Insel, 2010; Kotov et al., 2017).

Biomarkers are measurable biological features that reflect physiological processes and can indicate normal or pathological functioning in the body. They may also correlate with the presence or severity of disease (García-Gutiérrez et al., 2020; Kang, 2009). Recent research has identified a variety of physiological, inflammatory, neural, endocrine, and other biological responses that may be associated with psychopathology and mental distress (Bear et al., 2017; Beauchaine & Thayer, 2015; Kim et al., 2018; Looser et al., 2010; O'Connor et al., 2021; Thayer & Lane, 2007).

Changes in the autonomic nervous system (ANS)—which governs involuntary functions such as heart rate, breathing, temperature regulation, and blood pressure—are frequently observed in individuals experiencing altered mood states (Thayer & Lane, 2007). One of the key metrics used to assess ANS activity, particularly cardiac vagal tone, is heart rate variability (HRV) (Thayer et al., 2012; Sgoifo et al., 2015). HRV reflects fluctuations in heart rate over time and is one of the most widely used physiological indicators for assessing connections between physiological and psychological domains (Beauchaine & Thayer, 2015).

Research into the links between HRV and psychological functions such as self-regulation and cognitive control has been ongoing for nearly two decades (Beauchaine & Thayer, 2015). HRV is now recognized as a noninvasive, accessible marker of adaptive regulation across physiological, cognitive, and emotional domains (Thayer et al., 2009; Weber et al., 2010). Higher HRV is generally associated with greater adaptive responsiveness to internal and external environmental changes (Harrewijn et al., 2018). In contrast, lower resting HRV reflects autonomic inflexibility, which has been linked to emotional dysregulation, reduced psychological flexibility, and impaired social functioning (Dekker et al., 2000; Chalmers et al., 2016).

In psychopathology research, low HRV has been associated with negative mental health outcomes, including anxiety (Hastings et al., 2014), phobias (Ahs et al., 2009), attention problems (Rash & Aguirre-Camacho, 2012), autism (Neuhaus et al., 2014), depression (Rottenberg, 2007), and stress (Jarczok et al., 2020). These findings hold even in the absence of cardiovascular disease (Carney et al., 2009; Schiweck et al., 2019) and may be more pronounced in cases of severe psychological distress (Kemp et al., 2010).

Among the various ways to measure HRV, resting-state HRV has become a common approach in psychopathology research (Kemp & Quintana, 2013). Resting HRV is associated with the experience and expression of social and emotional behaviors (Dantas et al., 2018; Porges & Furman, 2011). One study showed that young adults with higher resting HRV engaged more in social strategies and exhibited greater capacity to regulate negative emotions compared to those with lower HRV (Geisler et al., 2013). Another study by Stone et al. (2018) found that women with a history of depression and childhood emotional abuse showed significantly reduced resting HRV.

Systematic reviews provide strong evidence that HRV may serve as a useful endophenotype for psychological dysfunction (Koch et al., 2019; Schiweck et al., 2019; Sgoifo et al., 2015). Harrewijn et al. (2018) examined whether HRV during induced stress could be a candidate endophenotype for generalized anxiety disorder (GAD). While they concluded that HRV is a promising biomarker associated with internalizing disorders and may reflect a transdiagnostic genetic vulnerability, it was not identified as a specific endophenotype for GAD.

These findings reinforce the idea that physiological markers may be present across various mental health conditions but remain nonspecific—thus supporting a transdiagnostic view of psychopathology and its connection to internalizing symptoms. Given the evidence of HRV alterations in several mental disorders and other health conditions, HRV appears to be a promising transdiagnostic biomarker (Beauchaine & Thayer, 2015).

In conclusion, although the dimensional study of psychopathology has gained momentum in recent years, few studies have specifically investigated HRV as a general, transdiagnostic biomarker of mental health (Beauchaine & Thayer, 2015). This is especially true when examining internalizing symptoms (i.e., anxiety, depression, and stress) that are prevalent across many current diagnostic categories. Accordingly, the present study aimed to investigate the association between resting HRV and internalizing symptoms (anxiety, depression, and stress). The primary hypothesis was that internalizing symptoms would show a negative correlation with HRV, highlighting its potential as a physiological, transdiagnostic biomarker (Beauchaine & Thayer, 2015). The secondary hypothesis was that individuals with a self-reported mental health diagnosis would exhibit higher levels of internalizing symptoms and, consequently, lower HRV (Chalmers et al., 2016).

## Method

This study employed a quantitative, correlational design. This type of design aims to assess the strength of the relationship between variables without inferring causality (Dancey & Reidy, 2018). Data collection took place between November and December 2021.

## Participants

A non-probabilistic, convenience sample was used. Eligible participants were Brazilian-born individuals aged between 18 and 40. Exclusion criteria included self-reported chronic physical illnesses (e.g., heart disease, hypertension, diabetes, cancer), pregnancy or lactation, a body mass index (BMI) greater than 35, and the consumption of stimulants (e.g., coffee, energy drinks) within 8 hours prior to the physiological assessment.

This study is a secondary analysis based on the dataset from Rocha-Oliveira and Zibetti (2022). Sample size was determined using G\*Power software, based on the correlation between worry and HRV ( $r = .31$ ) reported in the study by Quintana, Alvares, and Heathers (2016). Considering an 80% statistical power and a two-tailed distribution, the required sample size was calculated to be 60 participants.

The final sample consisted of 60 individuals between the ages of 18 and 40 ( $M = 28.53$ ,  $SD = 5.85$ ). Of these, 76.7% were women ( $n = 46$ ) and 23.3% were men ( $n = 14$ ). The mean BMI was 25.45 ( $SD = 4.20$ ). Regarding marital status, 65.0% were single, and 63.3% ( $n = 38$ ) had completed higher education.

Half of the participants (50.0%,  $n = 30$ ) self-reported a mental health diagnosis made by a psychologist or psychiatrist. The most frequently reported diagnoses were anxiety disorders (36.7%,  $n = 11$ ) and mood disorders (33.3%,  $n = 10$ ). Furthermore, 33.3% ( $n = 10$ ) of those with a self-reported diagnosis indicated the presence of at least one comorbid psychiatric condition.

## Instruments

- a. Online Screening Questionnaire. A brief questionnaire developed specifically for this study to assess inclusion and exclusion criteria. It was administered online prior to the data collection phase to individuals who volunteered to participate.
- b. Sociodemographic Questionnaire. This questionnaire was designed to collect demographic and health-related information in order to describe and characterize the sample.
- c. Depression, Anxiety, and Stress Scale – 21 Items (DASS-21) (Lovibond & Lovibond, 1995; Brazilian adaptation by Vignola, 2013). This Likert-type scale assesses symptoms of depression, anxiety, and stress, with responses ranging from “0 – Did not apply to me at all” to “3 – Applied to me very much, or most of the time.” The scale consists of three subscales (Depression, Anxiety, and Stress), with seven items each, for a total of 21 items. Higher scores indicate greater negative affectivity. Cronbach’s alpha values for the Brazilian version were .92 for Depression, .90 for Stress, and .86 for Anxiety (Vignola, 2013; Martins et al., 2019).
- d. Polar H10 Heart Rate Variability Monitor. HRV data were collected using the Polar H10 heart rate sensor, which uses two chest-mounted electrodes secured with an elastic strap to measure cardiac activity. Recordings were taken while participants were seated and at rest. HRV data were transmitted via Bluetooth to a smartphone and visually inspected for artifacts using the Elite HRV app (version 5.3.0). The data were then transferred to a

computer, where preprocessing was performed using Kubios HRV software (Matlab™ – version 3.4.1, Finland). HRV analysis was conducted using the RMSSD parameter, which represents the root mean square of successive differences between adjacent heartbeats, measured in milliseconds (Shaffer & Ginsberg, 2017). RMSSD is a valid and stable domain for assessing vagally mediated HRV at rest (Thayer et al., 2012) and is considered a reliable index of parasympathetic activity (Vanderlei et al., 2009).

### Data collection procedure

Initially, volunteers completed a brief online questionnaire that screened for inclusion and exclusion criteria, serving as a preliminary step for study enrollment. Individuals who met the criteria were then invited to participate in the in-person data collection phase. All participants signed the informed consent form (ICF) before participating in the study.

The in-person data collection took place in a quiet room with a controlled temperature between 21 and 23 °C. Participants were instructed in advance to avoid consuming stimulants or caffeine for at least eight hours prior to the session. The first step in this phase was to attach the Polar H10 Heart Transmitter chest strap to the participant, positioned at the level of the xiphoid process. Participants were then seated comfortably and asked to complete the sociodemographic questionnaire. Early placement of the chest strap allowed participants to acclimate to the device and for any necessary positional adjustments to be made before the HRV recording began.

Once the sociodemographic questionnaire was completed, HRV data collection was initiated. The recording lasted five minutes and was conducted during the participant's resting state. During this period, participants sat quietly, focusing on a blank screen with no external stimuli. After the HRV measurement, the chest strap was removed, and participants were asked to complete the Depression, Anxiety, and Stress Scale (DASS-21) (Lovibond & Lovibond, 1995; Brazilian adaptation by Vignola, 2013).

### Ethical Considerations

The larger research project from which this study derives was approved by the Ethics Committee of the *Universidade do Vale do Rio dos Sinos* (UNISINOS, University of Vale do Rio dos Sinos) via the Plataforma Brasil system (CAAE: 40555420.0.0000.5344), in accordance with Resolution No. 510/2016 of the *Conselho Nacional de Saúde* (CNS, Brazilian National Health Council, 2016). All participants signed an informed consent form and received psychoeducational materials related to the study topic afterward.

### Data analysis procedure

Data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 22.0). Descriptive statistics were first calculated to characterize the sample. The Shapiro–Wilk test indicated that the data did not follow a normal distribution. Therefore, nonparametric

analyses were used. Due to the distribution and small sample size, a bootstrap procedure with 1,000 resamples and a 95% confidence interval was applied.

Spearman's rank-order correlations were conducted to assess associations between HRV and the following DASS-21 scores: Total, Anxiety, Depression, and Stress. Additionally, group differences were examined using the Mann-Whitney U test. All analyses adopted a significance level of  $p < .05$ .

## Results

As an initial control step, the influence of sociodemographic variables—age, BMI, and gender—on HRV was examined. BMI was not significantly correlated with resting HRV ( $\rho = .13$ ,  $p = .30$ ), and no significant differences in HRV were observed between women and men ( $U = 304.000$ ,  $z = -0.315$ ,  $p = .75$ ). The only variable that showed a significant association with HRV was age, which demonstrated a negative correlation ( $\rho = -.35$ ,  $p < .01$ ). Age was partially controlled for by the inclusion criteria.

To assess the relationship between internalizing symptoms and HRV, Spearman correlations were calculated between resting HRV and DASS-21 scores (Total, Anxiety, Depression, and Stress), as shown in Table 1.

**Table 1**

*Correlation Between HRV and DASS-21 in the Total Sample.*

	$\rho$ (rho)	HRV	
		95% CI	P
DASS-T	-0.506	-0.696 to -0.262	<0.01
DASS-A	-0.317	-0.553 to -0.061	0.014
DASS-D	-0.521	-0.686 to -0.306	<0.01
DASS-S	-0.349	-0.579 to -0.071	<0.01

*Legend:*  $\rho$  = Spearman's rho; CI = Confidence Interval;  $p < .05$ ; DASS-T = DASS-Total; DASS-A = DASS-Anxiety; DASS-D = DASS-Depression; DASS-S = DASS-Stress.

The correlation results indicated that HRV in the total sample was significantly associated with all DASS-21 score variables—that is, the higher the DASS-21 score, the lower the heart rate variability. Moderate negative correlations were observed for the DASS-Total and DASS-Depression scores, and weak negative correlations were found for the DASS-Anxiety and DASS-Stress scores. To expand upon the data obtained from the total sample, additional correlations were conducted between HRV and DASS-21 scores (DASS-Total, DASS-Anxiety, DASS-Depression, and DASS-Stress) based on the presence or absence of a self-reported mental disorder. These correlations are presented in Table 2.

**Table 2**

*Correlation Between HRV and DASS-21 by Groups*

	DASS-T		DASS-A		DASS-D		DASS-S					
	$\rho$	CI (95%)	$p$	$\rho$	CI (95%)	$p$	$\rho$	CI (95%)	$p$			
<b>With diagnosis</b>	-0.519	-0.753 to -0.204	<0.01	-0.237	-0.580 to 0.133	0.207	-0.480	-0.739 to -0.139	<0.01	-0.430	-0.675 to -0.062	0.018
<b>Without diagnosis</b>	-0.097	-0.459 to 0.344	0.611	0.019	-0.358 to 0.426	0.922	-0.191	-0.518 to 0.203	0.311	-0.013	-0.401 to 0.397	0.948

Legend:  $\rho$  = Spearman's rho; CI = Confidence Interval;  $p < .05$ ; DASS-T = DASS-Total; DASS-A = DASS-Anxiety; DASS-D = DASS-Depression; DASS-S = DASS-Stress.

The results indicated that HRV was significantly associated with the group reporting a mental disorder. A moderate negative correlation was found for DASS-Total, DASS-Depression, and DASS-Stress scores. No significant correlation was observed for the DASS-Anxiety score. In the group without a self-reported mental disorder, no significant correlations were found.

Based on this result, it was decided to conduct a Mann-Whitney test to compare HRV levels between the groups according to clinical status. See Table 3.

**Table 3**

*Comparative HRV Data by Group*

	Mean (SD)	Mean Rank	U	$p$
<b>With diagnosis</b>	22.67 (11.31)	20.87	161.00	<0.01
<b>Without diagnosis</b>	42.85 (19.39)	59.28		

Legend: U = Mann-Whitney; significance  $p < .05$ .

Based on the mean HRV values for the groups with and without a self-reported mental disorder, it is evident that the group reporting a disorder exhibited reduced HRV compared to the group without such a report. This procedure was repeated to further explore the sample, this time comparing the DASS-21 total scores between the groups according to clinical status, as described in Table 4.

**Table 4**

*Comparative DASS-Total Data by Group*

	Mean (SD)	Mean Rank	U	$p$
<b>With diagnosis</b>	28.80 (17.93)	39.68	174.50	<0.01
<b>Without diagnosis</b>	13.80 (8.49)	21.32		

Legend: U = Mann-Whitney; significance  $p < .05$ .

These results show that the group with a mental disorder had significantly higher DASS-21 scores than the group without a disorder, reinforcing the scale's relevance for identifying internalizing symptoms.

### Discussion

This study aimed to examine the relationship between resting HRV levels and internalizing symptoms. In the general sample, all DASS-21 measures showed significant negative correlations with HRV. In other words, the greater the severity of internalizing symptoms, the lower the heart rate variability. This result supports existing literature indicating an association between the presence and intensity of psychological symptoms and reduced HRV (Conway, 2016; Kemp et al., 2010). It is also in line with previous research suggesting that HRV may be considered a transdiagnostic biomarker of internalizing symptoms (Harrewijn et al., 2018).

The initial analyses were extended by dividing the sample into groups based on the presence or absence of a self-reported mental disorder. This division was guided by a categorical understanding of mental disorders, aiming to identify how internalizing symptoms are experienced by individuals with a psychopathological diagnosis.

Participants in the group with a diagnosed mental disorder showed significant correlations between HRV and stress, depression, and total scores (which reflect internalizing symptoms). The fact that only anxiety scores in the clinical group did not correlate with HRV was unexpected (Tomasi et al., 2024a, 2024b), especially considering that anxiety disorders were among the most frequent diagnoses in that group. This result raises questions about the self-report measurement of anxiety symptoms and also contributes to the understanding of other potential hypotheses. For example, it aligns with evidence on the heterogeneity of symptom manifestations within the same disorder (Clark et al., 2017), and with the high rate of comorbidities, which makes it difficult for current diagnostic criteria to adequately classify these phenomena. These findings highlight the importance of a dimensional perspective to better understand the levels of pathology and psychological distress (Clark et al., 2017; Kotov et al., 2017).

In contrast, among participants without a self-reported mental disorder, no significant relationships were observed between HRV and internalizing symptoms. These findings suggest that dividing participants based on diagnostic status (even using broad categories) may be an important factor for identifying the relationship between physiological changes and internalizing symptom severity. It is therefore plausible that the attribution of a mental disorder diagnosis – regardless of the specific condition – is associated with increased internalizing symptoms, contributing to physiological alterations.

Although this assumption requires further investigation, it was observed that participants with a mental disorder diagnosis had lower mean HRV and higher mean DASS-21 scores. This may again indicate that the physiological alterations observed are accompanied by internalizing symptoms and are not better explained by another health condition (Carney et al., 2009; Schiweck et al., 2019). Similarly, the group without a self-reported diagnosis showed higher HRV

and lower DASS-21 scores, which have been interpreted in the literature as indicative of greater adaptive capacity (Harrewijn et al., 2018).

HRV data have also been used to predict internalizing symptoms and the trajectories of these symptoms in both adolescents and adults (Wen et al., 2024). On the other hand, internalizing symptoms are not the only psychological variables associated with HRV. For instance, a recent meta-analysis found an association between HRV and emotional dysregulation in youth, which may also encompass externalizing manifestations (Bellato et al., 2024). Therefore, it is possible that other psychological variables may help explain a reduction in HRV.

This study has some important limitations that must be acknowledged. The small sample size and the reliance on self-reported diagnoses for the clinical group limit the generalizability of the findings. Nevertheless, this study contributes to demonstrating the potential of the DASS-21 as an accessible and effective tool for assessing internalizing symptoms such as anxiety, depression, and stress.

Another noteworthy aspect is the potential of HRV as a simple, non-invasive, and low-cost psychophysiological measure for clinical use. Resting HRV allows for the assessment of ANS influence on heart rate and provides psychophysiological insights into an individual's physical and mental health (Vanderlei et al., 2009). This type of measure contributes to psychophysiological research, particularly in identifying valid and clinically applicable biological markers (Thayer et al., 2009; Weber et al., 2010).

Based on the findings, it is evident that internalizing symptom severity is related to HRV, and the hypothesis of HRV as a transdiagnostic physiological biomarker is supported, aligning with a dimensional model. However, the study also underscores the importance of considering categorical diagnostic classification, as the absence of a diagnosis was associated with higher HRV and lower internalizing symptom scores. Ultimately, these findings highlight the complexity of studying and developing systems for classifying both categorical and dimensional aspects of mental disorders. They also emphasize the importance of linking physiological measures to clinical practice to promote the refinement and evolution of models for understanding mental health.

### **Final Considerations**

HRV proved to be a potential transdiagnostic biomarker of internalizing symptoms. Future studies with larger samples and a focus on exploring causal relationships may further clarify the connection between these phenomena.

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**Sophie S. T. Sodré:** designed the study, analyzed and interpreted the data, and wrote the first draft of the manuscript.

**Daiane Rocha-Oliveira:** designed the study, analyzed and interpreted the data, and wrote the first draft of the manuscript.

**Murilo R. Zibetti:** interpreted the data and critically revised the content.

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