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# Somatic Symptoms and Its Association With Anxiety and Interoception

## [Gejala Somatik dan Hubungannya Dengan Kecemasan dan Interosepsi]

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In Somatic Symptom Disorder, individuals may misinterpret their symptoms as signs of disease. Meanwhile, interoception refers to an individual's perception to sense internal body sensations. Interoception may play a role in the regulation of state and trait anxiety. Anxiety, in turn, is associated with somatic symptoms. A comprehensive study regarding somatic symptoms is still required to fill the knowledge gap regarding its relationships with other variables. In this study, 101 university students from Nagoya, Japan, fulfilled four questionnaires related to the study variables. The participants also completed the heartbeat counting task (HCT) to assess interoceptive accuracy and heart rate variability (HRV) measurement. The results showed that health concerns and trait anxiety are associated with somatic symptoms. In addition, the sub-scales Attention Regulation and Self-Regulation determined trait anxiety in an inverse correlation. These results suggest that interoception, particularly interoceptive sensibility, is negatively associated with trait anxiety regarding somatic symptoms. The inverse relationship could be expected, as interoceptive sensibility is a set of positive beliefs about aspects of the individual's abilities and the tendency to consciously sense signals originating from inside their body.

**Keywords:** somatic symptoms, health concerns, trait anxiety, interoception, heart rate variability (HRV)

Pada Gangguan Gejala Somatik, individu mungkin menafsirkan gejalanya sebagai tanda dari suatu penyakit. Sementara itu, interosepsi mengacu pada persepsi individu terhadap sensasi yang dirasakan dalam tubuhnya. Interosepsi dapat berperan dalam regulasi kecemasan, baik *state* maupun *trait*. Kecemasan, dalam perannya, terkait dengan gejala somatik. Studi komprehensif mengenai gejala somatik masih diperlukan untuk mengisi kesenjangan pengetahuan mengenai keterkaitannya dengan variabel lain. Dalam studi ini, 101 mahasiswa dari kota Nagoya, Jepang, mengisi empat kuesioner terkait variabel studi. Partisipan juga menyelesaikan *heartbeat counting task (HCT)* untuk mengukur *interoceptive accuracy* dan pengukuran *heart rate variability (HRV)*. Hasil menunjukkan bahwa kecemasan terhadap kesehatan dan *trait anxiety* berkaitan dengan gejala somatik. Selain itu, sub-skala *Attention Regulation* dan *Self-Regulation* menunjukkan hubungan negatif dengan *trait anxiety*. Hasil ini menunjukkan bahwa interosepsi, khususnya *interoceptive sensibility*, berkorelasi negatif dengan *trait anxiety* terkait gejala somatik. Relasi negatif ini dapat dipahami karena *interoceptive sensibility* adalah seperangkat keyakinan positif tentang aspek kemampuan individu dan kecenderungan untuk secara sadar merasakan sinyal yang berasal dari dalam tubuhnya.

**Kata kunci:** gejala somatik, kecemasan terhadap kesehatan, *trait anxiety*, interosepsi, variabilitas detak jantung

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Psychological factors are related to somatic symptoms. The relationship has been previously investigated, and were found to be significantly correlated with negative affect (Kvaal & Patodia, 2000; Leventhal et al., 1996). Individuals with high negative affect scores typically complain of frequent somatic symptoms and predicted poorer physical health (Lovis-Schmidt et al., 2022; Dunn et al., 2010; Pennebaker, 2000). Previous studies suggest that negative emotions potentially impact health and physiological functions, such as the immune system, and generate somatic complaints (Leventhal et al., 1996; Rahal et al., 2023).

Headache, back pain, racing heartbeat, and dizziness are forms of somatic symptoms. In the Diagnostic and Statistical Manual of Mental Disorders (DSM), complaints concerning somatic or bodily symptoms may result in the diagnosis of Somatization Disorder (based on the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition [DSM-IV] criteria) or Somatic Symptom Disorder (based on the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition [DSM-5] criteria). Based on the Diagnostic and Statistical Manual of Mental Disorder Fifth Edition (DSM-5)'s Diagnostic Criteria, it is divided into two criteria: (1) Criterion A; and (2) Criterion B. Having one or more distressing symptoms that are distressing or result in significant disruption in daily life meets Criterion A. Meanwhile, excessive thoughts, feelings, or behaviors related to the somatic symptoms or associated health concerns as manifested by: (1) disproportionate and persistent thoughts concerning the seriousness of one's somatic symptoms; (2) a persistently high level of anxiety about health or somatic symptoms; or (3) excessive time and energy devoted to those symptoms are the essential symptoms for Criterion B of Somatic Symptom Disorder (American Psychiatric Association [APA], 2013).

Anxiety plays a role in many psychological disorders (Nolen-Hoeksema, 2020), including Somatic Symptom Disorder. In addition, state anxiety (particularly anxiety over health) is correlated with somatic symptoms (Maulina, 2016). The characteristic response of anxiety itself includes: (1) somatic; (2) emotional; (3) cognitive; and (4) behavioral features. Anxiety also may relate positively to interoception, in that individuals with high levels of trait anxiety tend to show attentional biases and a negative belief system about interoceptive cues (Khalsa et al., 2018). Heightened interoception as a biological vulnerability may be involved in the development of pathological anxiety, in addition to

Faktor psikologis berhubungan dengan gejala somatik. Hubungan tersebut telah diselidiki sebelumnya, dan ditemukan berkorelasi signifikan dengan *affect* negatif (Kvaal & Patodia, 2000; Leventhal et al., 1996). Individu dengan skor *affect* negatif yang tinggi biasanya mengeluhkan gejala somatik yang sering terjadi dan cenderung memiliki kesehatan fisik yang lebih buruk (Lovis-Schmidt et al., 2022; Dunn et al., 2010; Pennebaker, 2000). Sejumlah studi sebelumnya menunjukkan bahwa emosi negatif berpotensi berdampak pada kesehatan dan fungsi fisiologis, seperti sistem kekebalan tubuh, dan menimbulkan keluhan somatik (Leventhal et al., 1996; Rahal et al., 2023).

Sakit kepala, nyeri punggung, detak jantung berdebar kencang, dan pusing merupakan bentuk gejala somatik. Dalam *Diagnostic and Statistical Manual of Mental Disorders (DSM)*, keluhan mengenai gejala somatik atau tubuh dapat berakibat pada diagnosis Gangguan Somatisasi (berdasarkan kriteria *Diagnostic and Statistical Manual of Mental Disorders Fourth Edition [DSM-IV]*) atau Gangguan Gejala Somatik (berdasarkan kriteria *Diagnostic and Statistical Manual of Mental Disorders Fifth Edition [DSM-5]*). Berdasarkan Kriteria Diagnostik *Diagnostic and Statistical Manual of Mental Disorder Fifth Edition (DSM-5)*, dibagi menjadi dua kriteria: (1) Kriteria A; dan (2) Kriteria B. Memiliki satu atau lebih gejala mengganggu yang menyulitkan atau mengakibatkan gangguan signifikan dalam kehidupan sehari-hari memenuhi Kriteria A. Sementara itu, pikiran, perasaan, atau perilaku berlebihan terkait gejala somatik atau kecemasan terhadap kesehatan terkait yang diwujudkan dengan: (1) pemikiran yang tidak proporsional dan terus-menerus mengenai keseriusan gejala somatik individu; (2) tingkat kecemasan yang tinggi terhadap kesehatan atau gejala somatik; atau (3) waktu dan energi berlebihan yang dicurahkan untuk gejala tersebut merupakan gejala utama untuk Kriteria B dari Gangguan Gejala Somatik (American Psychiatric Association [APA], 2013).

Kecemasan berperan dalam banyak gangguan psikologis (Nolen-Hoeksema, 2020), termasuk Gangguan Gejala Somatik. Selain itu, *state anxiety* (khususnya kecemasan terhadap kesehatan) berkorelasi dengan gejala somatik (Maulina, 2016). Karakteristik respon kecemasan itu sendiri meliputi fitur atau ciri: (1) somatik; (2) emosional; (3) kognitif; dan (4) perilaku. Kecemasan juga mungkin berhubungan positif dengan interoepsi, ketika individu dengan tingkat *trait anxiety* yang tinggi cenderung menunjukkan bias perhatian dan sistem kepercayaan negatif tentang isyarat atau tanda interoseptif (Khalsa et al., 2018). Interoepsi yang meningkat sebagai kerentanan biologis mungkin terlibat dalam perkembangan kecemasan

psychological factors (Mallorquí-Bagué et al., 2016). Therefore, interoception may play a key role in the etiology and maintenance of state and trait anxiety (Domschke et al., 2010).

Interoception refers to the sense of the physiological condition of the body (Craig, 2002) and the representation of internal body states (Craig, 2009; Garfinkel et al., 2015). This incorporates a range of sensations, such as pain (LaMotte et al., 1982), temperature (Craig & Bushnell, 1994), and muscle tension (Light & Perl, 2003). Further, interoception has many features, such as: (1) attention; (2) detection; (3) magnitude; (4) discrimination; (5) accuracy; (6) sensibility; and (7) self-reporting (Garfinkel et al., 2015). Two of them, being interoceptive accuracy and interoceptive sensibility, are the focus of this study. Interoceptive accuracy is accurately detecting and tracking internal bodily sensations; an objective empirical measure of behavioral performance. A performance on objective behavioral tests of heartbeat detection is an example of interoceptive accuracy measurement. Meanwhile, interoceptive sensibility is defined as the subjective, self-evaluated characterological trait (from questionnaire measures) to be interoceptively focused (Terasawa et al., 2013).

The empirical evidence regarding the accuracy of interoception in Somatic Symptom Disorder is inconsistent. One study showed that high interoceptive accuracy is associated with Somatic Symptom Disorder (Scholz et al., 2001), but another study reported high symptoms associated with less interoceptive accuracy (Bogaerts et al., 2008). Higher interoceptive accuracy may be the result of stronger bodily signals or of a stronger allocation of attentional resources to bodily sensations (Rief & Barsky, 2005; Salkovskis & Warwick, 2001). The concepts of interoceptive accuracy and interoceptive sensibility are related but somewhat independent. Interoceptive sensibility, identified with interoceptive bodily awareness in Mehling's study, is described as an individual's set of beliefs regarding aspects of their abilities and their tendency to consciously sense internal physical signals (Mehling et al., 2012). Eight concepts were adopted by Mehling, assessed through a validated scale: (1) Noticing; (2) Not Distracting; (3) Not-Worrying; (4) Attention Regulation; (5) Emotional Awareness; (6) Self-Regulation; (7) Body Listening; and (8) Trusting. In addition, interoceptive accuracy can be measured objectively using the heartbeat counting task (HCT) in which participants are instructed to register their heartbeats without feeling for their pulse to determine

patologis, selain faktor psikologis (Mallorquí-Bagué et al., 2016). Maka dari itu, interoception mungkin memainkan peran kunci dalam etiologi dan pemeliharaan *state anxiety* dan *trait anxiety* (Domschke et al., 2010).

Interoepsi mengacu pada pengertian atau sensasi kondisi fisiologis tubuh (Craig, 2002) dan representasi keadaan internal tubuh (Craig, 2009; Garfinkel et al., 2015). Hal ini mencakup berbagai sensasi, seperti rasa sakit atau nyeri (LaMotte et al., 1982), suhu (Craig & Bushnell, 1994), dan ketegangan otot (Light & Perl, 2003). Lebih lanjut, interoepsi memiliki banyak ciri atau fitur, seperti: (1) *attention* (atensi); (2) *detection* (deteksi); (3) *magnitude* (besar); (4) *discrimination* (diskriminasi); (5) *accuracy* (akurasi); (6) *sensibility* (kepekaan); dan (7) *self-reporting* (pelaporan mandiri; Garfinkel et al., 2015). Dua di antaranya, *interoceptive accuracy* dan *interoceptive sensibility*, menjadi fokus studi ini. *Interoceptive accuracy* berhubungan dengan secara akurat mendeteksi dan melacak sensasi internal tubuh; ukuran empiris objektif dari kinerja perilaku. Kinerja tes perilaku obyektif deteksi detak jantung adalah contoh pengukuran *interoceptive accuracy*. Di sisi lain, *interoceptive sensibility* diartikan sebagai sifat atau *trait* karakterologis subjektif yang dievaluasi sendiri (dari ukuran kuesioner) yang terfokus pada interoseptif (Terasawa et al., 2013).

Bukti empiris mengenai keakuratan dari interoepsi pada Gangguan Gejala Somatik tidak konsisten. Terdapat satu studi yang menunjukkan bahwa *interoceptive accuracy* yang tinggi dikaitkan dengan Gangguan Gejala Somatik (Scholz et al., 2001), namun studi lain melaporkan gejala yang tinggi terkait dengan *interoceptive accuracy* yang lebih rendah (Bogaerts et al., 2008). *Interoceptive accuracy* yang lebih tinggi mungkin disebabkan oleh sinyal tubuh yang lebih kuat atau alokasi sumber perhatian yang lebih kuat terhadap sensasi tubuh (Rief & Barsky, 2005; Salkovskis & Warwick, 2001). Konsep *interoceptive accuracy* dan *interoceptive sensibility* saling berkaitan namun relatif independen. *Interoceptive sensibility*, yang diidentifikasi dengan kesadaran tubuh secara interoseptif dalam studi oleh Mehling, digambarkan sebagai seperangkat keyakinan individu mengenai aspek kemampuan mereka dan kecenderungan mereka untuk secara sadar merasakan sinyal fisik internal (Mehling et al., 2012). Delapan konsep yang diadopsi oleh Mehling, dinilai melalui skala yang tervalidasi: (1) *Noticing* (Memperhatikan); (2) *Not Distracting* (Tidak Mengganggu); (3) *Not-Worrying* (Tidak Khawatir); (4) *Attention Regulation* (Regulasi Atensi); (5) *Emotional Awareness* (Kesadaran Emosional); (6) *Self-Regulation* (Pengaturan Mandiri); (7) *Body Listening* (Mendengarkan Tubuh); dan (8)

the accuracy of their perceptions (Schandry, 1981). However, it remains unclear whether interoceptive sensibility or interoceptive accuracy (or both) are linked to somatic symptoms.

As noted, the presentations of anxiety in terms of health may develop from the underlying vulnerability of biological factors, such as interoception. In addition, somatic symptoms are a key feature of pathological and high-state anxiety and are linked to an acute activation of the sympathetic axis of the autonomic nervous system (ANS) and to the withdrawal of parasympathetic tone (Mallorquí-Bagué et al., 2016). Previous studies have investigated the relationship between the autonomic nervous system (ANS) and disorders related to somatic symptoms. Huang et al. (2017) suggested that various types of somatic symptoms are modulated by autonomic nervous system (ANS) activity. Patients who have somatization or Somatic Symptom Disorder have low heart rate variability (HRV; Hipwell et al., 2009), which is widely used to measure autonomic nervous system (ANS) activity. Standardized short-term measurement of heart rate variability (HRV; for five minutes) is generally used to estimate autonomic nervous system (ANS) activity (Huang et al., 2017; Malik et al., 1996). In particular, the component of high-frequency heart rate variability (HF-HRV) is associated with parasympathetic activity, and there is a stronger sympathetic component in low-frequency heart rate variability (LF-HRV). Therefore, heart rate variability (HRV) may be associated with somatic symptoms.

Somatic symptoms that are supported by health anxiety or concerns emerges from the misattribution of normal bodily sensations for signs of an illness, according to a Cognitive-Behavioral Model. Individuals with these disorders often exhibit dysfunctional beliefs about illness, assuming that serious illnesses are common, and they typically misinterpret any physical changes as causes for concern. They believe that they are vulnerable to a variety of physical illnesses and are unable to tolerate pain. Furthermore, they typically experience bodily sensations more intensely than others, focus more on physical symptoms and health-related information,

*Trusting* (Percaya). Selain itu, *interoceptive accuracy* dapat diukur secara objektif dengan menggunakan *heartbeat counting task* (HCT; tugas penghitungan detak jantung), ketika partisipan diinstruksikan untuk mencatat detak jantungnya tanpa merasakan denyut nadinya untuk mengetahui keakuratan persepsinya (Schandry, 1981). Namun, masih belum jelas apakah *interoceptive sensibility* atau *interoceptive accuracy* (atau keduanya) berhubungan dengan gejala somatik.

Sebagaimana telah dijabarkan, gambaran kecemasan dalam kaitannya dengan kesehatan dapat berkembang dari kerentanan yang mendasari faktor biologis, seperti interoepsi. Selain itu, gejala somatik adalah ciri utama kecemasan patologis dan *state anxiety* yang tinggi dan terkait dengan aktivasi akut *axis simpatis autonomic nervous system* (ANS; sistem saraf otonom) dan penarikan nada parasimpatis (Mallorquí-Bagué et al., 2016). Sejumlah studi sebelumnya telah menyelidiki hubungan antara *autonomic nervous system* (ANS) dan gangguan yang berhubungan dengan gejala somatik. Huang et al. (2017) mengemukakan bahwa berbagai tipe gejala somatik dimodulasi oleh aktivitas *autonomic nervous system* (ANS). Pasien yang mengalami somatisasi atau Gangguan Gejala Somatik memiliki *heart rate variability* (HRV; variabilitas detak jantung) yang rendah (Hipwell et al., 2009), yang banyak digunakan untuk mengukur aktivitas *autonomic nervous system* (ANS). Pengukuran *heart rate variability* (HRV) jangka pendek (selama lima menit) yang terstandarisasi umumnya digunakan untuk memperkirakan aktivitas *autonomic nervous system* (ANS; Huang et al., 2017; Malik et al., 1996). Secara khusus, komponen *high-frequency heart rate variability* (HF-HRV; variabilitas detak jantung frekuensi tinggi) dikaitkan dengan aktivitas parasimpatis, dan terdapat komponen simpatis yang lebih kuat dalam *low-frequency heart rate variability* (LF-HRV; variabilitas detak jantung frekuensi rendah). Maka dari itu, *heart rate variability* (HRV) mungkin berhubungan dengan gejala somatik.

Gejala somatik yang didukung oleh kecemasan atau kekhawatiran terhadap kesehatan muncul dari kesalahan atribusi sensasi tubuh normal dengan tanda suatu penyakit, menurut *Cognitive-Behavioral Model* (Model Perilaku Kognitif). Individu dengan gangguan ini sering kali menunjukkan keyakinan disfungsi tentang penyakit, dengan asumsi bahwa penyakit serius adalah hal umum, dan mereka biasanya salah mengartikan perubahan fisik apa pun sebagai hal yang perlu dikhawatirkan. Mereka percaya bahwa mereka rentan terhadap berbagai penyakit fisik dan tidak mampu mentoleransi rasa sakit. Selain itu, mereka biasanya mengalami sensasi tubuh yang

and catastrophize the symptoms that they identify (Rief & Barsky, 2005; Witthöft et al., 2016). Thus, interoception could be involved in the development of health anxiety (Krautwurst et al., 2014). This model assumes that distressing somatic symptoms may arise from the cycle of noticing minor somatic symptoms, bodily hypervigilance, and predicting higher interoception. However, in the Predictive Processing Model, a less level of detail in sensory processing is assumed, predicting lower interoception (Witthöft et al., 2020).

Somatic symptom severity exists on a continuum. Studying non-clinical participants may allow an understanding of how somatic symptoms develop from ordinary health experiences (Freeston et al., 1994) and apprehend the feasibility of further study in a clinical sample. The current study hypothesis is as follows:

*Hypothesis:* The development of somatic symptoms is linked to anxiety and interoception.

While certain psychological and physiological factors that are associated with somatic symptoms have been examined separately, a comprehensive description of somatic symptoms has not emerged, that would include the causal relationship between anxiety and interoception in the development of somatic symptoms.

## Method

### Participants

In total, 101 university students (aged 18-25 years;  $M = 20.16$ ;  $SD = 1.60$ ; 49.5% men and 50.5% women) from the city of Nagoya, Japan, were recruited via e-mail and an announcement on the website of Nagoya University. All participants were healthy with no serious illness history. At the beginning of the study, the participants were provided with a printed information sheet detailing the study procedures, including their withdrawal rights. This study was conducted with the approval of the Ethics Committee of Nagoya University (NUPSY-180216-G-02). All participants completed previously validated questionnaires, heart rate variability (HRV) measurement, and heartbeat counting task (HCT)

lebih intens dibandingkan orang lain, lebih fokus pada gejala fisik dan informasi terkait kesehatan, dan merespon gejala yang mereka identifikasi sebagai sebuah bencana atau masalah (Rief & Barsky, 2005; Witthöft et al., 2016). Dengan demikian, interosepsi dapat terlibat dalam perkembangan kecemasan sehubungan dengan kesehatan (Krautwurst et al., 2014). Model ini mengasumsikan bahwa gejala somatik yang menyusahkan atau mengganggu mungkin timbul dari siklus memperhatikan gejala somatik kecil, kewaspadaan tubuh yang berlebihan, dan memprediksi interosepsi yang lebih tinggi. Namun, dalam *Predictive Processing Model* (Model Pemrosesan Prediktif), diasumsikan tingkat detail dalam pemrosesan sensorik lebih rendah, sehingga memprediksi interosepsi yang lebih rendah (Witthöft et al., 2020).

Tingkat keparahan gejala somatik ada pada suatu kontinum. Mempelajari partisipan non-klinis dapat memberikan pemahaman tentang bagaimana gejala somatik berkembang dari pengalaman kesehatan biasa atau umum (Freeston et al., 1994) dan memahami kelayakan studi lebih lanjut dalam sampel klinis. Hipotesis studi ini adalah sebagai berikut:

*Hipotesis:* Perkembangan gejala somatik terkait dengan kecemasan dan interosepsi.

Walaupun faktor psikologis dan fisiologis tertentu yang berhubungan dengan gejala somatik telah diteliti secara terpisah, gambaran komprehensif tentang gejala somatik belum tersedia, yang mencakup hubungan sebab-akibat antara kecemasan dan interosepsi dalam perkembangan gejala somatik.

## Metode

### Partisipan

Secara total, 101 mahasiswa (berusia 18-25 tahun;  $M = 20,16$ ;  $SD = 1,60$ ; 49,5% laki-laki dan 50,5% perempuan) dari kota Nagoya, Jepang, direkrut melalui *e-mail* dan pengumuman di situs *web Nagoya University*. Seluruh partisipan dalam keadaan sehat tanpa riwayat penyakit serius. Pada awal studi, partisipan disediakan lembar informasi tercetak yang merinci prosedur studi, termasuk hak penarikan diri. Studi ini dilaksanakan dengan persetujuan *Ethics Committee of Nagoya University* (NUPSY-180216-G-02). Semua partisipan menyelesaikan kuesioner yang telah divalidasi sebelumnya, pengukuran *heart rate variability (HRV)*, dan *heartbeat counting task (HCT)* di laboratorium. Durasi sesi untuk tiap

in a laboratory setting. The duration of the session for each participant was approximately 40 minutes, and all participants provided informed consent.

## Materials

### *Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale (PHQ-15)*

The Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale (PHQ-15) assessed somatic symptoms severity (Kroenke et al., 2002; Muramatsu, 2014). This scale has 15 items, used to measure the prevalence of the most common body symptoms experienced by participants. Responses are given on a 3-point scale, in the range of: “1 (*Not Bothered At All*)”, “2 (*Bothered a Little*)”, and “3 (*Bothered a Lot*)”. The item measuring menstruation problems for women was excluded from this study. The Cronbach’s  $\alpha$  value for the scale was .698.

### *Somatic Symptom Disorder-B Criteria Scale (SSD-12)*

The Somatic Symptom Disorder-B Criteria Scale (SSD-12; Toussaint et al., 2015) was utilized to measure health concerns or health anxiety. This scale includes 12 items across three domains or sub-criteria (with four items each), which are: (1) cognitive; (2) affective; and (3) behavioral. The responses are given on a five-point scale, in the range of: “0 (*Never*)”, “1 (*Rarely*)”, “2 (*Sometimes*)”, “3 (*Often*)”, and “4 (*Very Often*)”. The higher score indicates the somatic symptoms severity. The Cronbach’s  $\alpha$  for this scale was .796.

### *State-Trait Anxiety Inventory (STAI)*

Spielberger’s State-Trait Anxiety Inventory (STAI) was utilized to measure participants’ anxiety (Shimizu & Imae, 1981; Spielberger et al., 1983). The State-Trait Anxiety Inventory (STAI) included of 40-items on a 4-point scale, in the range of: “1 (*Not At All*)” to “4 (*Very Much So*)”, of which 20 items measured anxiety levels at the present moment (Cronbach’s  $\alpha = .806$ ) and 20 items measured anxiety levels as a personal characteristic (Cronbach’s  $\alpha = .863$ ).

### *Multidimensional Assessment of Interoceptive Awareness (MAIA)*

The authors utilized the Multidimensional Assessment of Interoceptive Awareness (MAIA) to assess interoceptive

partisipan adalah sekitar 40 menit, dan semua partisipan telah memberikan persetujuan via *informed consent*.

## Materi

### *Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale (PHQ-15)*

*Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale (PHQ-15)* menilai tingkat keparahan gejala somatik (Kroenke et al., 2002; Muramatsu, 2014). Skala ini memiliki 15 butir, yang digunakan untuk mengukur prevalensi gejala tubuh yang paling umum dialami partisipan. Respons diberikan dalam skala tiga poin, dengan rentang: “1 (Tidak Terganggu Sama Sekali)”, “2 (Sedikit Terganggu)”, dan “3 (Sangat Terganggu)”. Butir yang mengukur masalah menstruasi pada perempuan tidak digunakan dalam studi ini. Nilai Cronbach’s  $\alpha$  untuk skala ini adalah 0,698.

### *Somatic Symptom Disorder-B Criteria Scale (SSD-12)*

*Somatic Symptom Disorder-B Criteria Scale (SSD-12; Toussaint et al., 2015)* digunakan untuk mengukur kecemasan terhadap kesehatan. Skala ini mencakup 12 butir pada tiga domain atau sub-kriteria (masing-masing berisi empat butir), yaitu: (1) kognitif; (2) afektif; dan (3) perilaku. Respons diberikan dalam skala lima poin, dengan rentang: “0 (Tidak Pernah)”, “1 (Jarang)”, “2 (Terkadang)”, “3 (Sering)”, dan “4 (Sangat Sering)”. Skor yang lebih tinggi menunjukkan tingkat keparahan gejala somatik. Cronbach’s  $\alpha$  untuk skala ini adalah 0,796.

### *State-Trait Anxiety Inventory (STAI)*

*State-Trait Anxiety Inventory (STAI)* dari Spielberger digunakan untuk mengukur kecemasan partisipan (Shimizu & Imae, 1981; Spielberger et al., 1983). *State-Trait Anxiety Inventory (STAI)* mencakup 40 butir pada skala empat poin, dalam rentang: “1 (Tidak Sama Sekali)” hingga “4 (Sangat Banyak)”, ketika 20 butir mengukur tingkat kecemasan saat ini (Cronbach’s  $\alpha = 0,806$ ) dan 20 butir mengukur tingkat kecemasan sebagai karakteristik pribadi (Cronbach’s  $\alpha = 0,863$ ).

### *Multidimensional Assessment of Interoceptive Awareness (MAIA)*

Para penulis menggunakan *Multidimensional Assessment of Interoceptive Awareness (MAIA)* untuk menilai

sensibility (Mehling et al., 2012; Shoji et al., 2018). Interoceptive sensibility is defined as a conscious level of interoception with its multiple dimensions potentially accessible to self-report. Multidimensional Assessment of Interoceptive Awareness (MAIA) consists of 32 self-rated statements that take responses on a 6-point scale, in the range of: “0 (*Never*)” to “5 (*Always*)”. Higher scores of each dimension indicate higher interoceptive sensibility for each. The instrument is divided into eight sub-scales, and the Cronbach’s  $\alpha$  value for each ranged between .501 - .878.

The eight sub-scales are: (1) Noticing (awareness of body sensation) with  $\alpha = .547$ ; (2) Not Distracting (tendency to ignore or distract oneself from sensations of pain or discomfort) with  $\alpha = .663$ ; (3) Not-Worrying (emotional distress or worrying about sensations of pain or discomfort) with  $\alpha = .501$ ; (4) Attention Regulation (ability to sustain and control attention to body sensation) with  $\alpha = .878$ ; (5) Emotional Awareness (awareness of the connection between body sensations and emotional states) with  $\alpha = .747$ ; (6) Self-Regulation (ability to regulate psychological distress through attention to body sensations) with  $\alpha = .569$ ; (7) Body Listening (actively listening to the body for insight) with  $\alpha = .841$ ; and (8) Trusting (experiencing one’s body as safe and trustworthy) with  $\alpha = .755$ .

For the Japanese participants in this study, the Noticing sub-scale showed inconsistencies in reliability (Kabir, 2019). Further, in line with previous studies of the Japanese version of the Multidimensional Assessment of Interoceptive Awareness (MAIA), the sub-scale for Not-Worrying showed poor internal consistency, so it should be interpreted with caution (Fujino, 2019). In addition, discrepancies in reliability for the Not-Worrying sub-scale have been reported in previous studies but have since been addressed in the revised Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2018).

### ***Heartbeat Counting Task (HCT)***

Interoceptive accuracy was measured using a version of the heartbeat counting task (HCT; Schandry, 1981). Interoceptive accuracy is the ability to detect internal body sensations (such as heartbeat) accurately. The heartbeat counting task (HCT) is frequently used to measure interoceptive accuracy and continues to be used

*interoceptive sensibility* (Mehling et al., 2012; Shoji et al., 2018). *Interoceptive sensibility* didefinisikan sebagai tingkat interosepsi yang disadari dengan berbagai dimensi yang berpotensi dapat diakses untuk dilaporkan sendiri. *Multidimensional Assessment of Interoceptive Awareness (MAIA)* terdiri dari 32 pernyataan yang dinilai sendiri dan direspon dalam skala enam poin, dalam rentang: “0 (Tidak Pernah)” hingga “5 (Selalu)”. Skor yang lebih tinggi dari tiap dimensi menunjukkan *interoceptive sensibility* yang lebih tinggi untuk tiap dimensi. Instrumen ini dibagi menjadi delapan sub-skala, dan nilai Cronbach’s  $\alpha$  untuk tiap sub-skala berkisar antara 0,501 - 0,878.

Delapan sub-skala tersebut adalah: (1) *Noticing* (kesadaran terhadap sensasi tubuh) dengan  $\alpha = 0,547$ ; (2) *Not Distracting* (kecenderungan mengabaikan atau mengalihkan perhatian dari sensasi nyeri atau tidak nyaman) dengan  $\alpha = 0,663$ ; (3) *Not-Worrying* (distress emosional atau khawatir akan sensasi sakit atau tidak nyaman) dengan  $\alpha = 0,501$ ; (4) *Attention Regulation* (kemampuan mempertahankan dan mengontrol perhatian terhadap sensasi tubuh) dengan  $\alpha = 0,878$ ; (5) *Emotional Awareness* (kesadaran akan hubungan antara sensasi tubuh dan keadaan emosi) dengan  $\alpha = 0,747$ ; (6) *Self-Regulation* (kemampuan mengatur tekanan psikologis melalui perhatian terhadap sensasi tubuh) dengan  $\alpha = 0,569$ ; (7) *Body Listening* (mendengarkan tubuh secara aktif untuk mendapatkan wawasan) dengan  $\alpha = 0,841$ ; dan (8) *Trusting* (mengalami atau merasa bahwa tubuh aman dan dapat dipercaya) dengan  $\alpha = 0,755$ .

Bagi partisipan Jepang dalam studi ini, sub-skala *Noticing* menunjukkan ketidakkonsistenan dalam reliabilitas (Kabir, 2019). Lebih lanjut, sejalan dengan sejumlah studi sebelumnya mengenai *Multidimensional Assessment of Interoceptive Awareness (MAIA)* versi Bahasa Jepang, sub-skala untuk *Not-Worrying* menunjukkan konsistensi internal yang buruk, sehingga harus ditafsirkan dengan hati-hati (Fujino, 2019). Selain itu, perbedaan reliabilitas untuk sub-skala *Not-Worrying* telah dilaporkan dalam studi sebelumnya, namun telah ditanggapi dalam *Multidimensional Assessment of Interoceptive Awareness (MAIA)* yang telah direvisi (Mehling et al., 2018).

### ***Heartbeat Counting Task (HCT)***

*Interoceptive accuracy* diukur menggunakan sebuah versi dari *heartbeat counting task (HCT)*; Schandry, 1981). *Interoceptive accuracy* adalah kemampuan mendeteksi sensasi internal tubuh (seperti detak jantung) secara akurat. *Heartbeat counting task (HCT)* sering digunakan untuk mengukur *Interoceptive accuracy* dan terus digunakan

$$\text{Heartbeat Perception Score} = \frac{1}{3} \sum \left( 1 - \frac{\text{Recorded Heartbeats} - \text{Counted Heartbeats}}{\text{Recorded Heartbeats}} \right)$$

Figure 1. Formula for heartbeat perception (HB perception) score.

to represent interoceptive accuracy measure in recent publications (Koreki et al., 2021; Schenk et al., 2020). In the adapted heartbeat counting task (HCT), the participants were asked to avoid relying on non-interoceptive signals and to only report the heartbeats that they perceived (Desmedt et al., 2018, 2020).

The participants were instructed to count their heartbeats silently and avoid relying on any heart rate estimation. The counting periods were 25, 35, and 45 seconds. However, participants not made aware of the duration of each counting period. The instruction to count heartbeats was presented using a computer monitor with “Start” and “Stop” directions. Participants wrote down their responses after each counting period. During this task, electrodes were attached to both wrists of the participants to allow a comparison of actual with counted heartbeats.

The sum of actual heartbeats and the sum of counted heartbeats were averaged over the three counting periods (25, 35, and 45 seconds). A heartbeat perception (HB perception) score was calculated using the formula (Pollatos & Schandry, 2004) described in Figure 1. A score of 1 represents perfect accuracy of heartbeat counting, and the score creases as more heartbeats are missed (or extra heartbeats are counted). Higher heartbeat perception (HB perception) scores indicate higher interoceptive accuracy.

### Heart Rate Variability (HRV)

Participants’ heart rate variability (HRV) was measured using a BIOPAC Systems’ MP150 electrocardiogram data recording system. Typically, short-term heart rate (HR) recording duration is at least five minutes for heart

untuk mewakili ukuran *Interoceptive accuracy* dalam publikasi terbaru (Koreki et al., 2021; Schenk et al., 2020). Dalam *heartbeat counting task (HCT)* yang diadaptasi, partisipan diminta untuk menghindari mengandalkan sinyal non-interoseptif dan hanya melaporkan detak jantung yang mereka rasakan atau persepsikan (Desmedt et al., 2018, 2020).

Para partisipan diinstruksikan untuk menghitung detak jantung mereka tanpa bersuara dan tanpa mengandalkan estimasi detak jantung apa pun. Periode penghitungannya adalah 25, 35, dan 45 detik. Namun, partisipan tidak mengetahui durasi tiap periode penghitungan. Instruksi penghitungan detak jantung disajikan menggunakan monitor komputer dengan petunjuk “Start” dan “Stop”. Partisipan menuliskan respons atau hasil mereka setelah tiap periode penghitungan. Selama tugas ini berlangsung, elektroda dipasang pada kedua pergelangan tangan partisipan untuk memungkinkan perbandingan detak jantung aktual dengan detak jantung yang dihitung.

Jumlah detak jantung sebenarnya dan jumlah detak jantung yang dihitung dikalkulasikan reratanya setelah tiga periode penghitungan (25, 35, dan 45 detik). *Heartbeat perception (HB Perception) score* (skor persepsi detak jantung) dihitung menggunakan rumus (Pollatos & Schandry, 2004) yang dideskripsikan dalam Gambar 1. Skor 1 mewakili akurasi penghitungan detak jantung yang sempurna, dan skor bertambah seiring semakin banyak detak jantung yang terlewat (atau detak jantung ekstra). *Heartbeat perception (HB perception) score* yang lebih tinggi menunjukkan *interoceptive accuracy* lebih tinggi.

### Heart Rate Variability (HRV)

*Heart rate variability (HRV)* partisipan diukur dengan menggunakan sistem perekaman data elektrokardiogram MP150 dari BIOPAC Systems. Biasanya, durasi pencatatan *heart rate (HR)*; detak jantung) jangka pendek adalah

$$\text{Skor Persepsi Detak Jantung} = \frac{1}{3} \sum \left( 1 - \frac{\text{Detak Jantung Terekam} - \text{Detak Jantung Terhitung}}{\text{Detak Jantung Terekam}} \right)$$

Gambar 1. Formula untuk *heartbeat perception (HB perception) score* (skor persepsi detak jantung).



rate variability (HRV) analysis (Malik et al., 1996). The participants had electrodes attached to both wrists for heart rate (HR) measurement. The measurement began when the researcher pressed the start button to measure heart rate variability (HRV). For this measure, the participants were asked to remain in a resting state in the daytime in an electrically shielded room. While undergoing measures, they were instructed to sit calmly in a chair and not fall asleep or seek to intentionally control their breathing.

The heart rate variability (HRV) was only analyzed during the rest period. RR intervals (from two successive R waves in the heart rate variability [HRV] measurement) were calculated from the pulse wave data using the software AcqKnowledge 4.2 of BIOPAC Systems, and then Kubios heart rate variability (HRV) software was used for the heart rate variability (HRV) analysis. The frequency-domain indices were used in this study's analysis. In particular, the high-frequency heart rate variability (HF-HRV; .15 - .40 Hz) is associated with parasympathetic activity. The low-frequency/high-frequency (LF/HF) ratio has previously been used as an index of sympathovagal balance. The low-frequency heart rate variability (LF-HRV; .04 - .15 Hz) is associated with stronger sympathetic activity (Huang et al., 2017; Malik et al., 1996). In addition, the low-frequency/high-frequency (LF/HF) ratio was examined, following other studies on heart rate variability (HRV) related to somatic symptoms and well-being (Huang et al., 2017; Shiga et al., 2021).

## Data Analysis

International Business Machines (IBM) Statistical Product and Service Solutions (SPSS) Version 27 was utilized for the Pearson correlation to assess the relationship between the variables. Statistical analyses of the independent-sample t-test was utilized to compare the means between men and women. The findings were interpreted and discussed at a significance level of .05. In addition, the statistical program HAD Version 17 (utilized in Microsoft Excel) was adopted for structural equation modeling (SEM) to examine the association between interoceptive sensibility, health concerns, trait anxiety, and somatic symptoms (Shimizu, 2016).

## Results

The participants were aged 18-25 years ( $M = 20.16$ ;  $SD = 1.60$ ). There were 50 men (49.5%;  $M_{men} = 20.28$  years;

setidaknya lima menit untuk analisis *heart rate variability* (HRV; Malik et al., 1996). Para partisipan memasang elektroda di kedua pergelangan tangan untuk pengukuran *heart rate* (HR). Pengukuran dimulai ketika peneliti menekan tombol *start* untuk mengukur *heart rate variability* (HRV). Untuk pengukuran ini, para partisipan diminta untuk tetap dalam kondisi istirahat pada siang hari di ruangan berpelindung listrik. Saat menjalani pengukuran, mereka diinstruksikan untuk duduk dengan tenang di kursi dan tidak tertidur atau dengan sengaja mengontrol pernapasan.

*Heart rate variability* (HRV) hanya dianalisis selama waktu istirahat. Interval RR (dari dua gelombang R berturut-turut dalam pengukuran *heart rate variability* [HRV]) dihitung dari data gelombang pulsa menggunakan perangkat lunak *AcqKnowledge 4.2* dari *BIOPAC Systems*, dan kemudian perangkat lunak *Kubios heart rate variability* (HRV) digunakan untuk analisis *heart rate variability* (HRV). Indeks domain frekuensi digunakan dalam analisis studi ini. Secara khusus adalah *high-frequency heart rate variability* (HF-HRV; 0,15 - 0,40 Hz) dikaitkan dengan aktivitas parasimpatis. Indeks domain *low frequency/high frequency* (LF/HF) sebelumnya telah digunakan sebagai indeks keseimbangan *sympathovagal*. *Low frequency heart rate variability* (LF-HRV; 0,04 - 0,15 Hz) dikaitkan dengan aktivitas simpatis yang lebih kuat (Huang et al., 2017; Malik et al., 1996). Selain itu, rasio *low-frequency/high-frequency* (LF/HF) juga diperiksa, mengikuti studi lain tentang *heart rate variability* (HRV) yang terkait dengan gejala somatik dan kesejahteraan (Huang et al., 2017; Shiga et al., 2021).

## Analisis Data

*International Business Machines* (IBM) *Statistical Product and Service Solutions* (SPSS) Versi 27 digunakan untuk korelasi *Pearson* demi menilai hubungan antar variabel. Analisis statistik *t-test* sampel independen digunakan untuk membandingkan rerata antara laki-laki dan perempuan. Temuan tersebut diinterpretasikan dan didiskusikan pada tingkat signifikansi 0,05. Selain itu, program statistik *HAD* Versi 17 (digunakan dalam *Microsoft Excel*) diadopsi untuk *structural equation modeling* (SEM) demi menguji hubungan antara *interoceptive sensibility*, kecemasan terhadap kesehatan, *trait anxiety*, dan gejala somatik (Shimizu, 2016).

## Hasil

Partisipan studi berusia 18-25 tahun ( $M = 20,16$ ;  $SD = 1,60$ ). Jumlah partisipan laki-laki sebanyak 50 orang (49,5%;

Table 1  
*Descriptive Statistics*

	<i>M</i>	<i>SD</i>
Somatic Symptoms	18.029	- 3.213
Health Concerns	16.04	- 4.764
Trait Anxiety	44.941	- 9.646
Interoceptive Sensibility		
IS - Noticing	2.285	- 0.885
IS - Not Distracting	2.71	- 1.05
IS - Not-Worrying	2.429	- 1.001
IS - Attention Regulation	2.42	- 0.907
IS - Emotional Awareness	2.606	- 0.969
IS - Self-Regulation	2.733	- 0.809
IS - Body Listening	1.809	- 1.097
IS - Trusting	2.677	- 1.075
Interoceptive Accuracy	0.704	- 0.181
HRV		
TP-HRV [ $\ln(\text{ms}^2)$ ]	6.771	- 0.928
LF-HRV [ $\ln(\text{ms}^2)$ ]	6.046	- 0.935
HF-HRV [ $\ln(\text{ms}^2)$ ]	5.728	- 1.214
LF/HF-HRV [ $\ln(\text{ratio})$ ]	2.194	- 2.664
Mean HR (bpm)	78.495	- 11.193

*Notes.* IS = Interoceptive Sensibility; HRV = Heart Rate Variability; TP = Total Power; LF = Low-Frequency; HF = High-Frequency; LF/HF = Ratio of Low-Frequency Power to High-Frequency Power; HR = Heart Rate; M = Mean; SD = Standard Deviation; LN = Natural Logarithm Function; MS = Millisecond; BPM = Beats Per Minute.

$SD = 1.873$ ) and 51 women (50.5%;  $M_{\text{women}} = 20.05$  years;  $SD = 1.287$ ). Table 1 provides more detailed information regarding the descriptive statistics of the studied variables.

Correlational analyses found positive relationships between health concerns (assessed using the Somatic Symptom Disorder-B Criteria Scale [SSD-12]) and somatic symptoms (assessed using the Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale [PHQ-15];  $p < .01$ ). In addition, somatic symptoms were positively related to trait anxiety ( $p < .01$ ). Health concerns positively correlated with trait anxiety ( $p < .01$ ), but reflected negative correlations with interoceptive sensibility (the Not-Worrying, Attention Regulation, Self-Regulation, and Trusting sub-scales;  $p < .01$ ). More detailed information regarding correlation test results is available in Table 2.

The authors found no negative correlation between mean heart rate (HR) and interoceptive accuracy ( $p < .01$ ). However, the authors also found no correlations in the relationships between other physiological and psychological indices, with the exception of a negative correlation between low-frequency/high-frequency heart

Tabel 1  
*Statistik Deskriptif*

	<i>M</i>	<i>SD</i>
Gejala Somatik	18,029	- 3,213
Kecemasan Terhadap Kesehatan	16,04	- 4,764
Trait Anxiety	44,941	- 9,646
Interoceptive Sensibility		
IS - Noticing	2,285	- 0,885
IS - Not Distracting	2,71	- 1,05
IS - Not-Worrying	2,429	- 1,001
IS - Attention Regulation	2,42	- 0,907
IS - Emotional Awareness	2,606	- 0,969
IS - Self-Regulation	2,733	- 0,809
IS - Body Listening	1,809	- 1,097
IS - Trusting	2,677	- 1,075
Interoceptive Accuracy	0,704	- 0,181
HRV		
TP-HRV [ $\ln(\text{ms}^2)$ ]	6,771	- 0,928
LF-HRV [ $\ln(\text{ms}^2)$ ]	6,046	- 0,935
HF-HRV [ $\ln(\text{ms}^2)$ ]	5,728	- 1,214
LF/HF-HRV [ $\ln(\text{ratio})$ ]	2,194	- 2,664
Mean HR (bpm)	78,495	- 11,193

*Catatan.* IS = Interoceptive Sensibility; HRV = Heart Rate Variability; TP = Total Power; LF = Low-Frequency; HF = High-Frequency; LF/HF = Rasio Low-Frequency Power to High-Frequency Power; HR = Heart Rate; M = Mean; SD = Standard Deviation; LN = Natural Logarithm Function; MS = Millisecond; BPM = Beats Per Minute.

$M_{\text{men}} = 20,28$  tahun;  $SD = 1,873$ ) dan perempuan sebanyak 51 orang (50,5%;  $M_{\text{women}} = 20,05$  tahun;  $SD = 1,287$ ). Tabel 1 menyediakan informasi lebih rinci mengenai statistik deskriptif variabel yang diteliti.

Analisis korelasional menemukan hubungan positif antara kecemasan terhadap kesehatan (dinilai menggunakan *Somatic Symptom Disorder-B Criteria Scale [SSD-12]*) dan gejala somatik (dinilai menggunakan *Patient Health Questionnaire 15-Item Somatic Symptom Severity Scale [PHQ-15]*;  $p < 0,01$ ). Sebagai tambahan, gejala somatik berhubungan positif dengan *trait anxiety* ( $p < 0,01$ ). Kecemasan terhadap kesehatan berkorelasi positif dengan *trait anxiety* ( $p < 0,01$ ), namun mencerminkan korelasi negatif dengan *interoceptive sensibility* (sub-skala *Not-Worrying*, *Attention Regulation*, *Self-Regulation*, dan *Trusting*;  $p < 0,01$ ). Informasi lebih detail sehubungan dengan hasil uji korelasi terdapat pada Tabel 2.

Para penulis tidak menemukan korelasi negatif antara rerata *heart rate (HR)* dan *interoceptive accuracy* ( $p < 0,01$ ). Namun, para penulis juga tidak menemukan korelasi dalam hubungan antara indeks fisiologis dan psikologis lainnya, dengan pengecualian korelasi negatif antara *low-frequency/high-frequency heart rate variability*

rate variability (LF/HF-HRV) with health concerns and trait anxiety ( $p < .05$ ; see Table 2). The mean comparison analysis between men and women found differences in somatic symptoms and interoceptive accuracy. However, no differences were seen between men and women for any heart rate variability (HRV) indices. More detailed information regarding the comparison of mean scores between men's and women's data is available in Table 2.

The analysis of the assumed path (Figure 2) between interoceptive sensibility, health concerns, trait anxiety, and somatic symptoms showed a good fit ( $\chi^2 = 2.969$ ;  $df = 4$ ;  $p = .563$ , *root mean square error of approximation [RMSEA]* = .000; *comparative fit index [CFI]* = 1.000). Furthermore, the model indicated that health concerns ( $p < .05$ ) and trait anxiety ( $p < .001$ ) were positively associated with somatic symptoms. Health concerns associated with somatic symptoms ( $p < .05$ ) and may mediate the association between trait anxiety and somatic symptoms ( $\beta = .465$ ;  $SE = .031$ ;  $p < .001$ ). Interoceptive sensibility, particularly in the Attention Regulation and Self-Regulation subscales, showed negative associations with trait anxiety ( $p < .01$ ). Both interoceptive sensibility dimensions showed significant effect with trait anxiety (Attention Regulation sub-scale  $\beta = .319$ ;  $p < .01$ ; Self-Regulation sub-scale  $\beta = .259$ ;  $p < .05$ ) with  $R^2 = .258$ ;  $p < .001$ .

The addition of variables, such as other interoceptive sensibility sub-scales (Noticing, Not Distracting, Not Worrying, Emotional Awareness, Body Listening, and Trusting), interoceptive accuracy, and heart rate variability (HRV) measurement, showed no link. In addition, interoceptive accuracy and mean heart rate (HR) showed no associations with other variables in the model.

## Discussion

Somatic symptoms are associated with health concerns and trait anxiety. Furthermore, trait anxiety is negatively associated with interoceptive sensibility, particularly Attention Regulation and Self-Regulation sub-scales. The Multidimensional Assessment of Interoceptive Awareness (MAIA) sub-scales (Attention Regulation and Self-Regulation) were reversely associated with negative affect, and Attention Regulation has the strongest negative association with measures related to trait anxiety (Vig et al., 2022). The findings for the emergence

(LF/HF-HRV) dengan kecemasan terhadap kesehatan dan *trait anxiety* ( $p < 0,05$ ; lihat Tabel 2). Analisis perbandingan rerata antara laki-laki dan perempuan menunjukkan perbedaan pada gejala somatik dan *interoceptive accuracy*. Namun, tidak ada perbedaan yang terlihat antara laki-laki dan perempuan untuk indeks *heart rate variability (HRV)*. Informasi lebih detail sehubungan perbandingan skor rerata antara data laki-laki dan perempuan tersedia pada Tabel 2.

Analisis jalur yang diasumsikan (Gambar 2) antara *interoceptive sensibility*, kecemasan terhadap kesehatan, *trait anxiety*, dan gejala somatik menunjukkan *good fit* ( $\chi^2 = 2,969$ ;  $df = 4$ ;  $p = 0,563$ , *root mean square error of approximation [RMSEA]* = 0,000; *comparative fit index [CFI]* = 1,000). Lebih lanjut, model tersebut menunjukkan bahwa kecemasan terhadap kesehatan ( $p < 0,05$ ) dan *trait anxiety* ( $p < 0,001$ ) berhubungan positif dengan gejala somatik. Kecemasan terhadap kesehatan terkait dengan gejala somatik ( $p < 0,05$ ) dan dapat memediasi hubungan antara *trait anxiety* dan gejala somatik ( $\beta = 0,465$ ;  $SE = 0,031$ ;  $p < 0,001$ ). *Interoceptive sensibility*, khususnya pada sub-skala *Attention Regulation* dan *Self-Regulation*, menunjukkan hubungan negatif dengan *trait anxiety* ( $p < 0,01$ ). Kedua dimensi *interoceptive sensibility* menunjukkan pengaruh yang signifikan terhadap *trait anxiety* (sub-skala *Attention Regulation*  $\beta = 0,319$ ;  $p < 0,01$ ; sub-skala *Self-Regulation*  $\beta = 0,259$ ;  $p < 0,05$ ) dengan  $R^2 = 0,258$ ;  $p < 0,001$ .

Penambahan variabel, seperti sub-skala *interoceptive sensibility* lainnya (*Noticing, Not Distracting, Not Worrying, Emotional Awareness, Body Listening, dan Trusting*), *interoceptive accuracy*, dan pengukuran *heart rate variability (HRV)*, tidak menunjukkan adanya hubungan. Selain itu, *interoceptive accuracy* dan rerata *heart rate (HR)* tidak menunjukkan hubungan dengan variabel lain dalam model.

## Diskusi

Gejala somatik berhubungan dengan kecemasan terhadap kesehatan dan *trait anxiety*. Selain itu, *trait anxiety* berhubungan negatif dengan *interoceptive sensibility*, khususnya sub-skala *Attention Regulation* dan *Self-Regulation*. Sub-skala dari *Multidimensional Assessment of Interoceptive Awareness (MAIA; Attention Regulation dan Self-Regulation)* berhubungan terbalik dengan *affect* negatif, dan *Attention Regulation* memiliki hubungan negatif yang paling kuat dengan pengukuran yang berkaitan dengan *trait anxiety* (Vig et al., 2022). Temuan sehubungan

**Table 2**  
*Correlations Between Somatic Symptoms, Anxiety, Interoception, and Heart Rate Variability (HRV)*

	1	2	3	4a	4b	4c	4d	4e	4f	4g	4h	5	6	7	8	9
Somatic Symptoms																
Health Concerns	.382**															
Trait Anxiety	.416**	.400**														
IS - Noticing	.129	.121	.064													
IS - Not Distracting	.145	.222*	.194	.112												
IS - Not Worrying	.221*	.428**	.415**	.015	.342**											
IS - Attention Regulation	.253*	.224*	.467**	.329**	.164	.323**										
IS - Emotional Awareness	.087	.082	.155	.444**	.061	.025	.455**									
IS - Self-Regulation	.088	.209*	.440**	.239*	.127	.221*	.429**	.418**								
IS - Body Listening	.005	.014	.059	.229*	.054	.067	.226*	.508**	.422**							
IS - Trusting	.165	.138	.347**	.368**	.195	.128	.466**	.482**	.512**	.236*						
Interoceptive Accuracy	.162	.049	.094	.146	.193	.029	.069	.241*	.091	.044	.022					
TP-HRV [ln(ms <sup>2</sup> )]	.078	.024	.061	.097	.09	.009	.02	.051	.007	.049	.173	.097				
LF-HRV [ln(ms <sup>2</sup> )]	.035	.018	.012	.094	.077	.054	.042	.02	.056	.014	.125	.085	.926**			
HF-HRV [ln(ms <sup>2</sup> )]	.069	.101	.158	.072	.08	.103	.006	.051	.072	.049	.179	.112	.658**	.876**		
LF:HF-HRV [ln(ratio)]	.07	.216*	.253*	.027	.029	.233*	.067	.009	.119	.054	.075	.046	.106	.573**	.156	
Mean HR (bpm)	.027	.009	.075	.028	.066	.08	.021	.005	.06	.025	.081	.298**	.538**	.709**	.466**	.670**

*Notes.* IS = Interoceptive Sensibility; HRV = Heart Rate Variability; TP = Total Power; LF = Low-Frequency; HF = High-Frequency; LF:HF = Ratio of Low-Frequency Power to High-Frequency Power; HR = Heart Rate; LN = Natural Logarithm Function; MS = Millisecond; BPM = Beats Per Minute; \* $p < .05$ ; \*\* $p < .01$

Tabel 2  
Korelasi Antara Gejala Somatik, Kecemasan, Interoepsi, dan Heart Rate Variability (HRV)

	1	2	3	4a	4b	4c	4d	4e	4f	4g	4h	5	6	7	8	9
Gejala Somatik																
2	0.382*															
Kecemasan Keseluruhan																
3	0.416*	0.400*														
Trait Anxiety																
4a	0.129	0.121	0.064													
IS - Noticing																
4b	0.145	0.222*	0.194	0.112												
IS - Not Distracting																
4c	0.221*	0.428**	-0.415**	0.095	0.342**											
IS - Not Forgetting																
4d	-0.253*	-0.224*	-0.467**	0.329*	0.164	0.323**										
IS - Attention Regulation																
4e	0.087	-0.082	-0.155	0.444*	0.061	0.025	0.455**									
IS - Emotional Awareness																
4f	0.088	-0.209*	-0.440**	0.239*	0.127	0.221*	0.429**	0.418**								
IS - Self-Regulation																
4g	0.005	0.014	-0.059	0.229*	-0.054	-0.067	0.226*	0.508**	0.427**							
IS - Body Listening																
4h	-0.165	-0.138	-0.341**	0.368**	0.195	0.128	0.466**	0.482**	0.512**	0.236*						
IS - Trusting																
5	-0.162	-0.049	-0.094	-0.146	-0.195	0.029	-0.069	-0.241*	-0.091	-0.044	-0.022					
Interoceptive Accuracy																
6	0.078	-0.024	-0.061	0.097	-0.09	0.009	-0.02	0.051	0.007	0.049	0.173	0.097				
TP-HRV [ $\ln(\text{ms}^2)$ ]																
7	0.035	0.018	-0.012	0.094	-0.077	-0.054	-0.042	0.02	-0.056	0.014	0.125	0.085	0.926*			
LF-HRV [ $\ln(\text{ms}^2)$ ]																
8	0.069	-0.101	-0.158	0.072	-0.08	0.103	-0.006	0.051	0.072	0.049	0.179	0.112	0.658*	0.876**		
HF-HRV [ $\ln(\text{ms}^2)$ ]																
9	0.07	0.216*	0.253*	0.027	-0.029	-0.233*	-0.067	0.009	-0.119	0.054	-0.075	-0.046	0.106	-0.573*	0.156	
LF/HF-HRV [ $\ln(\text{ratio})$ ]																
10	0.027	0.09	0.075	-0.028	0.066	-0.08	0.021	0.005	0.06	0.025	-0.081	-0.298**	-0.538**	-0.709**	0.366**	-0.670**
Mean HR (bpm)																

Notes: IS = Interoceptive Sensibility, HRV = Heart Rate Variability, TP = Total Power, LF = Low-Frequency, HF = High-Frequency, LFFHF = Ratio Low-Frequency Power to High-Frequency Power, HR = Heart Rate, LN = Natural Logarithm Function, MS = Milliseconds, BPM = Beats Per Minute, \*  $p < 0.05$ , \*\*  $p < 0.01$ .

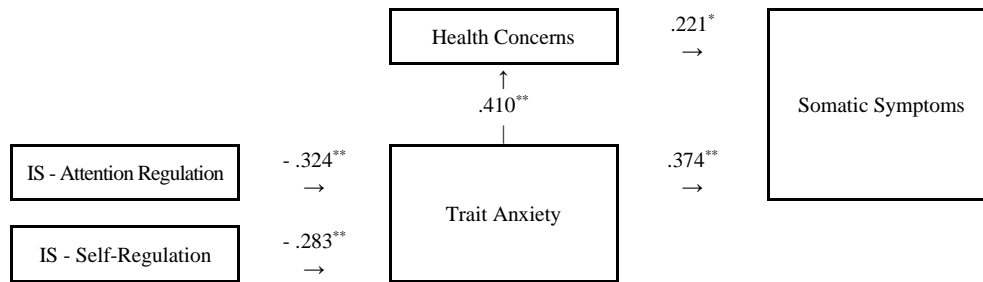


Figure 2. Model of association between somatic symptoms, anxiety, and interoceptive sensibility (Attention Regulation and Self-Regulation).

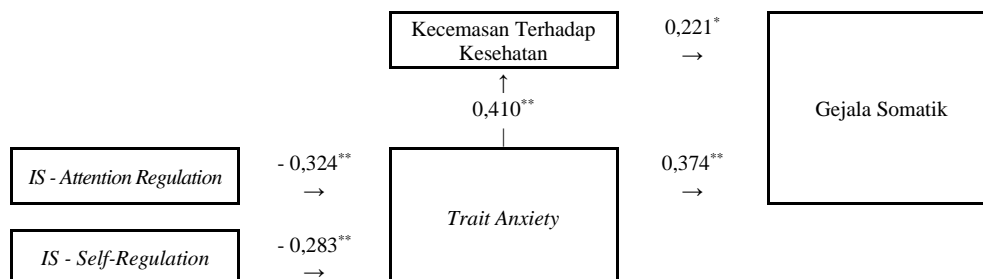
Notes. IS = Interoceptive Sensibility; \* $p < .05$ ; \*\* $p < .01$ .

of somatic symptoms from psychological factors were clear. Trait anxiety is consistently higher in individuals who have clinically higher health anxiety than those who do not (Maulina, 2016). In addition, somatic symptoms are strongly affected by negative affective traits and health anxiety or health concerns (Maulina, 2016; Pennebaker, 2000). Also, in one of the studies about competitive anxiety, somatic symptoms are the physical component of anxiety and a reflection of the perception of physiological response, in such forms as the increase in heart rate and muscle tension (Permadi & Nurwianti, 2019). Therefore, the results of this study align with the literature.

Assessment of interoceptive accuracy alone cannot provide a comprehensive evaluation of interoception. This study indicates that there are no associations between interoceptive accuracy, anxiety, and somatic symptoms. This independence of interoceptive accuracy aligns with the findings of Garfinkel et al. (2015), showing subjective self-report measures of interoception (e.g., those offered by the Multidimensional Assessment of Interoceptive Awareness [MAIA]) might significantly diverge from the objective measures of interoception.

munculnya gejala somatik dari faktor psikologis sudah jelas. *Trait anxiety* secara konsisten lebih tinggi pada individu yang memiliki kecemasan terhadap kesehatan yang secara klinis lebih tinggi dibandingkan mereka yang tidak (Maulina, 2016). Sebagai tambahan, gejala somatik sangat dipengaruhi oleh sifat afektif negatif dan kecemasan terhadap kesehatan atau masalah kesehatan (Maulina, 2016; Pennebaker, 2000). Selain itu, dalam salah satu studi mengenai kecemasan bersaing, gejala somatik merupakan komponen fisik dari kecemasan dan cerminan persepsi respon fisiologis, berupa peningkatan detak jantung dan ketegangan otot (Permadi & Nurwianti, 2019). Maka dari itu, hasil studi ini sejalan dengan literatur.

Penilaian *interoceptive accuracy* saja tidak dapat menyediakan evaluasi interoesepsi yang komprehensif. Studi ini menunjukkan bahwa tidak ada hubungan antara *interoceptive accuracy*, kecemasan, dan gejala somatik. Independensi *interoceptive accuracy* ini sejalan dengan temuan Garfinkel et al. (2015), menunjukkan ukuran interoesepsi yang dilaporkan mandiri secara subjektif (misalnya: yang disediakan oleh *Multidimensional Assessment of Interoceptive Awareness [MAIA]*) mungkin berbeda secara signifikan dari pengukuran objektif interoesepsi.



Gambar 2. Model hubungan antara gejala somatik, kecemasan, dan *interoceptive sensibility* (Attention Regulation dan Self-Regulation).

Catatan. IS = Interoceptive Sensibility; \* $p < 0,05$ ; \*\* $p < 0,01$ .

Also, the prior study indicated that interoceptive sensibility and interoceptive accuracy are temporally stable in the two-month measurement but unrelated to each other (Ferentzi et al., 2018). Another study found that only the Attention Regulation sub-scale of Multidimensional Assessment of Interoceptive Awareness (MAIA) is significantly but weakly associated with individual interoceptive accuracy (Cali et al., 2015). Nevertheless, the role of interoceptive accuracy requires further exploration. Witthöft et al. (2020) found that stronger symptom perception in the cardiorespiratory system, such as chest pain, racing heartbeat, and shortness of breath, was associated with lower interoceptive accuracy in a heterogeneous sample. These findings align more with the Predictive Processing Model than the Cognitive Behavioral Model, as the former suggests a less precise and biased interoceptive accuracy in the association with somatic symptom distress than the latter (Witthöft et al., 2020).

Among the Cognitive Behavioral Models, anxiety may arise from the misattribution of normal bodily sensations to signs of an illness symptom. In this study, interoceptive sensibility may closely describe the relationship between them. Interoceptive sensibility, as measured by Multidimensional Assessment of Interoceptive Awareness (MAIA), is the set of beliefs about aspects of the individual's own abilities and the tendency to consciously sense signals originating from inside their body (Mehling et al., 2012). The higher score in Multidimensional Assessment of Interoceptive Awareness (MAIA) represents more positive interoceptive sensibility. Attention Regulation (defined as the ability to sustain and control attention to body sensations) and Self-Regulation (the ability to regulate psychological distress by attention to body sensations) were evaluated positively. Thus, both interoceptive sensibility dimensions were negatively correlated with trait anxiety, reflecting a generally stable tendency to respond to perceived environmental threats. These findings suggest that trait anxiety is associated with interoceptive sensibility, as could be expected in an inverse relationship (Mehling et al., 2012). Individual trait interoception as a self-perceived dispositional tendency may contribute to the proneness of anxiety (Terasawa et al., 2013; Garfinkel & Critchley, 2013). In a previous study, interoceptive sensibility predicted its relationship with trait anxiety in undergraduate students and hospital nurses (Kabir, 2019). Palser et al.'s (2018) study results also showed that interoceptive sensibility may predict trait anxiety, in addition to another finding that alexithymia may mediate the relationship.

Selain itu, studi sebelumnya menunjukkan bahwa *interoceptive sensibility* dan *interoceptive accuracy* stabil untuk sementara dalam pengukuran dua bulan tetapi tidak berhubungan satu sama lain (Ferentzi et al., 2018). Studi lain menemukan bahwa hanya sub-skala *Attention Regulation* dari *Multidimensional Assessment of Interoceptive Awareness (MAIA)* yang secara signifikan, namun lemah, terkait dengan *interoceptive accuracy* individu (Cali et al., 2015). Walaupun demikian, peran *interoceptive accuracy* memerlukan eksplorasi lebih lanjut. Witthöft et al. (2020) menemukan bahwa persepsi gejala yang lebih kuat pada sistem kardiorespirasi, seperti nyeri dada, detak jantung berdebar kencang, dan sesak napas, dikaitkan dengan *interoceptive accuracy* yang lebih rendah dalam sampel heterogen. Temuan ini lebih sejalan dengan *Predictive Processing Model* dibandingkan dengan *Cognitive Behavioral Model*, karena model pertama menunjukkan *interoceptive accuracy* yang kurang tepat dan bias dalam kaitannya dengan *distress* gejala somatik dibandingkan model kedua (Witthöft et al., 2020).

Dalam *Cognitive Behavioral Model*, kecemasan mungkin timbul dari kesalahan atribusi sensasi tubuh normal dengan tanda gejala penyakit. Dalam studi ini, *interoceptive sensibility* dapat menggambarkan secara dekat hubungan di antara keduanya. *Interoceptive sensibility*, yang diukur dengan *Multidimensional Assessment of Interoceptive Awareness (MAIA)*, adalah seperangkat keyakinan tentang aspek kemampuan individu dan kecenderungan untuk secara sadar merasakan sinyal yang berasal dari dalam tubuhnya (Mehling et al., 2012). Skor yang lebih tinggi dalam *Multidimensional Assessment of Interoceptive Awareness (MAIA)* menunjukkan *interoceptive sensibility* yang lebih positif. *Attention Regulation* (didefinisikan sebagai kemampuan mempertahankan dan mengontrol perhatian pada sensasi tubuh) dan *Self-Regulation* (kemampuan untuk mengatur tekanan psikologis dengan memperhatikan sensasi tubuh) dinilai positif. Dengan demikian, kedua dimensi *interoceptive sensibility* berkorelasi negatif dengan *trait anxiety*, yang mencerminkan kecenderungan yang umumnya stabil untuk merespons ancaman lingkungan yang dirasakan. Temuan ini menunjukkan bahwa *trait anxiety* dikaitkan dengan *interoceptive sensibility*, seperti yang diharapkan dalam hubungan terbalik (Mehling et al., 2012). Interosepsi sifat individu sebagai kecenderungan disposisional yang dirasakan sendiri dapat berkontribusi terhadap rawannya kecemasan (Terasawa et al., 2013; Garfinkel & Critchley, 2013). Dalam studi sebelumnya, *interoceptive sensibility* memprediksi hubungannya dengan *trait anxiety* pada mahasiswa sarjana dan perawat rumah sakit (Kabir, 2019). Hasil studi Palser et al. (2018) juga menunjukkan

However, further investigation needs to clarify the reciprocal relationship between interoceptive sensibility and trait anxiety.

This study also found that body awareness, understood as perceived subjective body changes and states (interoceptive sensibility), may differ from heartbeat perception (HB perception; interoceptive accuracy). A recent study concluded that higher interoceptive sensibility (as measured by Multidimensional Assessment of Interoceptive Awareness [MAIA]) is associated with lower severity and frequency of symptoms, but this relationship is still unclear as it concerns interoceptive accuracy and awareness (Locatelli et al., 2023). Nevertheless, the authors did not find any relationship between interoceptive accuracy and anxiety or somatic symptoms. This study's findings may support the idea that interoceptive accuracy is not necessarily associated but rather predictive related to bodily sensations.

Heart rate variability (HRV) measurement has been widely applied in the mental health study, including somatic symptoms research. The low-frequency/high-frequency (LF/HF) ratio is used to indicate the amount of sympathovagal modulation of instantaneous heart rate (HR; Kleiger et al., 2005). A low low-frequency/high-frequency (LF/HF) ratio reflects parasympathetic dominance, while a high low-frequency/high-frequency (LF/HF) ratio indicates sympathetic dominance (Shaffer & Ginsberg, 2017). Numerous studies have been conducted using the low-frequency/high-frequency (LF/HF) ratio to examine its association with psychological states, including stress, anxiety, and well-being (Chang et al., 2020; Järvelin-Pasanen et al., 2018; Mizuno et al., 2011; Shiga et al., 2021), and psychological stress or anxiety was significantly has been found to be associated with increased low-frequency/high-frequency (LF/HF) ratio (Sloan et al., 1994). This study found no correlation between high-frequency (HF) and trait anxiety; however, the low-frequency/high-frequency (LF/HF) ratio and high-frequency (HF) showed a negative correlation. In a previous study, high-frequency (HF) was found to directly correlate with the severity of the functional somatic symptoms in adults. Another study found that high-frequency (HF) is negatively correlated with trait anxiety, and high anxiety levels are associated with reduced resting heart rate variability (HRV; Chalmers et al., 2014). A previous work supported these findings,

bahwa *interoceptive sensibility* dapat memprediksi *trait anxiety*, selain temuan lain bahwa *alexithymia* dapat memediasi hubungan tersebut. Namun, penyelidikan lebih lanjut perlu memperjelas hubungan timbal balik antara *interoceptive sensibility* dan *trait anxiety*.

Studi ini juga menemukan bahwa kesadaran tubuh, yang dipahami sebagai perubahan dan keadaan subjektif tubuh (*interoceptive sensibility*) yang dipersepsikan, mungkin berbeda dari *heartbeat perception* (HB perception; *interoceptive accuracy*). Sebuah studi baru ini menyimpulkan bahwa *interoceptive sensibility* yang lebih tinggi (yang diukur dengan *Multidimensional Assessment of Interoceptive Awareness [MAIA]*) dikaitkan dengan tingkat keparahan dan frekuensi gejala yang lebih rendah, namun hubungan ini masih belum jelas karena menyangkut *interoceptive accuracy* dan kesadaran (Locatelli et al., 2023). Walaupun demikian, para penulis tidak menemukan hubungan apa pun antara *interoceptive accuracy* dan kecemasan atau gejala somatik. Temuan studi ini mungkin mendukung gagasan bahwa *interoceptive accuracy* tidak selalu terkait melainkan bersifat prediktif sehubungan dengan sensasi tubuh.

Pengukuran *heart rate variability (HRV)* telah banyak diterapkan dalam studi kesehatan mental, termasuk riset gejala somatik. Rasio *low-frequency/high-frequency (LF/HF)* digunakan untuk menunjukkan jumlah modulasi *sympathovagal heart rate (HR)* sesaat (Kleiger et al., 2005). Rasio *low-frequency/high-frequency (LF/HF)* yang rendah mencerminkan dominasi parasimpatis, sedangkan rasio *low-frequency/high-frequency (LF/HF)* yang tinggi menunjukkan dominasi simpatis (Shaffer & Ginsberg, 2017). Sejumlah studi telah dilakukan menggunakan rasio *low-frequency/high-frequency (LF/HF)* untuk menguji hubungannya dengan keadaan psikologis, termasuk stres, kecemasan, dan kesejahteraan (Chang et al., 2020; Järvelin-Pasanen et al., 2018; Mizuno et al., 2011; Shiga et al., 2021), dan stres atau kecemasan psikologis secara signifikan ditemukan berhubungan dengan peningkatan rasio *low-frequency/high-frequency (LF/HF)*; Sloan et al., 1994). Studi ini tidak menemukan korelasi antara *high-frequency (HF)* dan *trait anxiety*; namun rasio *low-frequency/high-frequency (LF/HF)* dan *high-frequency (HF)* menunjukkan korelasi negatif. Dalam studi sebelumnya, *high-frequency (HF)* ditemukan berkorelasi langsung dengan tingkat keparahan gejala somatik fungsional pada orang dewasa. Studi lain menemukan bahwa *high-frequency (HF)* berkorelasi negatif dengan *trait anxiety*, dan tingkat kecemasan yang tinggi dikaitkan dengan penurunan *heart rate variability (HRV)* istirahat (Chalmers et al., 2014). Studi sebelumnya mendukung temuan ini,



indicating that individuals with high trait anxiety have a significantly lower high-frequency (HF) power than those with low trait anxiety (Miu et al., 2009). In this study, the low-frequency/high-frequency (LF/HF) ratio was correlated with anxiety, albeit weakly, as it was not being supported by the low-frequency (LF) or high-frequency (HF) correlation. This requires further exploration.

## Conclusion

The authors observed that health concerns and trait anxiety may contribute to somatic symptoms in a positive association. Interoceptive sensibility, represented by Attention Regulation and Self-Regulation sub-scales, provided a negative link with trait anxiety, as could be expected in an inverse relationship. This investigation also found that perceived subjective body changes and states (interoceptive sensibility) may differ from heartbeat perception (HB perception; interoceptive accuracy). The implications of this work may contribute to the intervention of somatic symptom and related disorder, such as in the mindfulness approach. Attention Regulation and Self-Regulation as part of interoceptive sensibility are closely related to mindfulness elements.

## Limitations and Suggestions

This study has several limitations. The heartbeat counting task (HCT) for the measurement of interoceptive accuracy may be affected by time estimation (Desmedt et al., 2020). Thus, the measure of interoceptive accuracy may include non-interoceptive processes (Desmedt et al., 2018). Consequently, another method for measuring interoception should be considered. In this study, the low-frequency/high-frequency (LF/HF) ratio and its relationship to health concerns and trait anxiety were measured over short periods and with a small sample size. Therefore, it is essential to measure the low-frequency/high-frequency (LF/HF) ratio over a more extended period. In addition, this study did not examine the neural mechanisms underlying the association among somatic symptoms, anxiety, and interoception. Previous studies have shown that brain regions such as the insula, anterior cingulate, and orbitofrontal cortices are associated with interoception, anxiety, and heart rate variability (HRV; Barrett & Simmons, 2015; Paulus & Stein, 2010). Disturbances in these systems might cause somatic symptoms. Therefore, further studies using neuroimaging are required to elucidate the alignment of neural mechanisms with the Predictive Processing Model.

menunjukkan bahwa individu dengan *trait anxiety* tinggi memiliki kekuatan *high-frequency (HF)* yang jauh lebih rendah dibandingkan mereka yang memiliki *trait anxiety* rendah (Miu et al., 2009). Dalam studi ini, rasio *low-frequency/high-frequency (LF/HF)* berkorelasi dengan kecemasan, meskipun lemah, karena tidak didukung oleh korelasi *low-frequency (LF)* atau *high-frequency (HF)*. Temuan ini memerlukan eksplorasi lebih lanjut.

## Simpulan

Para penulis mengamati bahwa kecemasan terhadap kesehatan dan *trait anxiety* dapat berkontribusi terhadap gejala somatik dalam hubungan yang positif. *Interoceptive sensibility*, yang diwakili oleh sub-skala *Attention Regulation* dan *Self-Regulation*, memberikan hubungan negatif dengan *trait anxiety*, seperti yang diharapkan dalam hubungan terbalik. Investigasi ini juga menemukan bahwa perubahan dan keadaan subjektif tubuh (*interoceptive sensibility*) mungkin berbeda dari *heartbeat perception (HB perception; interoceptive accuracy)*. Implikasi dari studi ini dapat berkontribusi pada intervensi gejala somatik dan gangguan terkait, seperti dalam pendekatan *mindfulness*. *Attention Regulation* dan *Self-Regulation* sebagai bagian dari *interoceptive sensibility* erat kaitannya dengan unsur *mindfulness*.

## Keterbatasan dan Saran

Studi ini memiliki beberapa keterbatasan. *Heartbeat counting task (HCT)* untuk pengukuran *interoceptive accuracy* mungkin dipengaruhi oleh estimasi waktu (Desmedt et al., 2020). Dengan demikian, pengukuran *interoceptive accuracy* dapat mencakup proses non-interoseptif (Desmedt et al., 2018). Maka dari itu, metode lain untuk mengukur interosepsi harus dipertimbangkan. Dalam studi ini, rasio *low-frequency/high-frequency (LF/HF)* dan hubungannya dengan kecemasan terhadap kesehatan dan *trait anxiety* diukur dalam jangka waktu singkat dan dengan ukuran sampel yang kecil. Oleh karena itu, penting untuk mengukur rasio *low-frequency/high-frequency (LF/HF)* dalam jangka waktu yang lebih lama. Selain itu, studi ini tidak meneliti mekanisme saraf yang mendasari hubungan antara gejala somatik, kecemasan, dan interosepsi. Studi sebelumnya menunjukkan bahwa daerah otak seperti *insula*, *anterior cingulate*, dan *orbitofrontal cortices* berhubungan dengan interosepsi, kecemasan, dan *heart rate variability (HRV)* (Barrett & Simmons, 2015; Paulus & Stein, 2010). Gangguan pada sistem ini mungkin menyebabkan gejala somatik. Maka dari itu, studi lebih lanjut menggunakan *neuroimaging* diperlukan untuk menjelaskan keselarasan mekanisme saraf dengan *Predictive Processing Model*.

This study was only conducted in Japan, and Asians likely emphasize physical symptoms rather than psychological expression. Hence, cultural influences might be involved. In addition, this study only described somatic symptoms and other variables for a university-based sample with a lower range of scores. Thus, future study in a more heterogeneous and larger sample is required to confirm the results, including a clinical sample with higher somatic symptoms scores.

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