



# Exploring the impact of trauma-adapted yoga in forensic psychiatry

Nora Kerekes<sup>a,b,\*</sup>

<sup>a</sup> Department of Health Sciences, University West, 461 86 Trollhättan, Sweden

<sup>b</sup> Centre for Holistic Psychiatry Research (CHoPy), 431 60 Mölndal, Sweden

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## ABSTRACT

The specialized field of forensic psychiatry deals with the care of criminal offenders who suffer from severe mental disorders. As this field is positioned at the intersection of illness, crime, and security, it poses complex challenges. While high-quality clinical studies in forensic psychiatry settings are limited, recent investigations have suggested yoga as a complementary clinical tool within correctional environments. This report of a quasi-experimental study examines the impact of a 10-week trauma-adapted yoga intervention on mental health, antisocial and aggressive behaviors, pain perception, cravings, and character maturity among 56 patients in various forensic psychiatry clinics across Sweden. In the current study, the yoga group demonstrated noteworthy reductions in negative affect states, anxiety, phobic anxiety, paranoid ideations, interpersonal sensitivity, hostility, and overall psychological distress. These reductions were not observed in the comparison group. Additionally, the yoga group exhibited a significant decrease in pain frequency and strengthened self-directedness. However, there were no significant changes in aggressive, antisocial, or self-harm behaviors or cravings in either group. The between-group analyses did not yield significant results, except for pain intensity. The trauma-adapted yoga intervention implemented within forensic psychiatry settings shows feasibility and results in multiple positive changes in patients' health.

## 1. Introduction

Forensic psychiatry is a specialized field that involves caring for offenders who have mental disorders (Svennerlind et al., 2010; Nedopil et al., 2015). Patients in forensic psychiatric care are involuntarily admitted; therefore, their autonomy is greatly limited. The court decides whether an offender should be sentenced to prison or forensic psychiatric care. A forensic psychiatric examination is conducted to form the basis for this decision. In such an examination, a multidisciplinary team (forensic psychiatrists, social workers, psychologists, and nursing staff) assesses the offender for the presence of any severe mental disorders at the time of the crime. Common diagnoses among patients receiving forensic psychiatric care include psychosis disorders such as schizophrenia, neurodevelopmental disorders, and some personality syndromes; these are often combined with substance abuse (Gorden, 2007; Degl' Innocenti et al., 2021; Laporte et al., 2021). Post-traumatic stress disorder (PTSD) is also exceptionally prevalent in this population; it affects approximately 50 % or more of these individuals (Kristiansson et al., 2004; Gariebballa et al., 2006; Bianchini et al., 2022). A substantial correlation has been observed between trauma and abuse in the

emergence of a personality disorder, highlighting the critical importance of intervention in addressing traumatic experiences among forensic psychiatric patients (Bianchini et al., 2022).

Staff members face several challenges when developing a high-quality care climate; they must consider crime and security issues while simultaneously treating and attempting to improve patients' mental health (Caplan, 1993; Hörberg, 2018). Forensic psychiatric care in Sweden is progressively shifting toward a more patient-centered approach, aligning with the ongoing developments in outpatient care. Consequently, there is a need for knowledge-based governance, or clinical guidelines based on research and clinical experiences (Ghavamabad et al., 2021). A high standard of care in forensic psychiatry is essential and, if effective, could lead to reductions in the risks of violence and recidivism (Olsson and Schön, 2016).

Yoga as a comprehensive discipline encompasses physical postures (asanas), controlled breathing (pranayama), and mindfulness practices. In its operational definition as a therapeutic intervention, yoga's impact on mental health is substantiated by a growing body of scientific evidence. Research employing magnetic resonance, functional magnetic resonance, and single-photon emission computerized tomography

\* Corresponding author.

E-mail address: [nora.kerekes@hv.se](mailto:nora.kerekes@hv.se).

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imaging technologies has demonstrated the positive effects of yoga on brain structure and function; these effects are associated with improved mental health outcomes (Gothe et al., 2019). The regular practice of yoga has been associated with reductions in stress, anxiety, PTSD symptoms, and depression; the alleviation of chronic pain; improved sleep patterns; and enhanced overall well-being and quality of life (Woodyard, 2011; Bridges and Sharma, 2017; Singphow et al., 2022; Dhamodhini et al., 2023; Zaccari et al., 2023).

Trauma-adapted yoga (TAY), a Swedish adaptation of trauma-informed yoga (TIY), is a specialized form of yoga that acknowledges the common biological changes in the autonomic and central nervous systems in patients within psychiatric care, particularly those with a high prevalence of exposure to complex trauma and PTSD (Justice et al., 2018). TAY is customized to meet the specific requirements of clinical settings and diverse patient groups, while also addressing the staff's need for stress management strategies. This method was designed to be sensitive to the needs of individuals diagnosed with psychiatric conditions and those who have experienced trauma. TAY modifies traditional yoga practices to be safe, inclusive, and supportive, aiming to foster a healthier relationship with one's body, encourage emotional regulation, and promote rehabilitation. Key elements of TAY, like those of TIY, include creating a safe environment that ensures physical and emotional safety, empowering participants with choices in their engagement, maintaining predictable structures, using invitational language, and focusing on the present-moment experience (Justice et al., 2018). The nexus of TAY with TIY and trauma-sensitive yoga lies in their shared objective of tailoring yoga practices for individuals with traumatic experiences. While these terms are often used interchangeably, they can also refer to distinct approaches within the broader context of yoga as a complementary care practice for psychiatric treatment interventions and trauma recovery.

Currently, there exists a dearth of research on the effects of yoga for patients undergoing care within the realm of forensic psychiatry, with the exception of a notable pilot study published in 2020 (Spinelli et al., 2020). This particular study, conducted among 13 forensic psychiatry patients, revealed compelling outcomes. Over an eight-week period, a combined yoga and mindfulness intervention yielded substantial enhancements in mindfulness and significant reductions in stress levels, with medium to large effect sizes (Spinelli et al., 2020).

However, yoga has gained considerable traction within correctional institutions over the past two decades, yielding captivating scientific insights. An expanding body of research has substantiated the manifold health advantages that yoga offers to incarcerated adults (Auty et al., 2017; Kerekes et al., 2017; Sfendla et al., 2018; Hopkins et al., 2019; Kerekes et al., 2019; Derlic, 2020). Of particular note, the feasibility and positive impacts of TIY have been demonstrated in institutionalized and community settings for young adults (Tibbitts et al., 2021). In Swedish correctional settings and randomized controlled trials, 10-week yoga interventions have yielded remarkable results, including improvements to incarcerated individuals' impulse control and attention, a decrease in antisocial behaviors, a transition from negative high arousal states to positive low arousal states (Kerekes et al., 2017), and reductions in obsessive and paranoid thoughts and somatization (Sfendla et al., 2018). Notably, this intervention led to a substantial enhancement in the self-directedness domain of the incarcerated individuals' character maturity (Kerekes et al., 2019). In these studies, yoga demonstrated its efficacy in addressing symptoms like apprehensive and fearful thoughts about relinquishing autonomy, memory difficulties, indecisiveness, concentration challenges, obsessive thoughts, and perceptions of bodily dysfunction (Sfendla et al., 2018). Moreover, yoga exhibited the potential to enhance incarcerated individuals' capacities to assume responsibility, foster a sense of purpose, and cultivate self-acceptance, all of which have shown correlations with reductions in aggressive and antisocial behaviors (Kerekes et al., 2019).

Given the prevalence of paranoid and psychotic thoughts, obsessions, impaired neuro-cognitive functions (Degl' Innocenti et al., 2021;

Laporte et al., 2021), and diminished self-control among patient populations in forensic psychiatry (Nilsson et al., 2016), it is relevant to explore the alterations in behaviors, mental health, and personalities that may be associated with yoga practice in forensic psychiatry settings. It is also imperative to specifically develop a yoga practice to address the negative effects of traumatic experiences for individuals in forensic psychiatric care. While such research will provide crucial information and advance the field of yoga research, it is important to note that these interventions are to be used alongside traditional measures.

The primary objective of the current study is to comprehensively examine the impacts of a TAY practice on the behaviors, mental health, and character maturity of individuals undergoing forensic psychiatric care. The study's overarching goal is to employ a range of validated behavioral and psychological assessments to gauge the outcomes of a 10-week TAY intervention. This intervention was specifically developed for the needs of this patient group, which encompasses both male and female patients from forensic psychiatric clinics in 10 locations across Sweden.

The central hypothesis suggested that 10 weeks of TAY practice would result in statistically significant decreases in the frequencies of aggressive, self-harming, and antisocial behaviors, a transition from predominantly negative to positive affect states, a reduction in psychological distress, and the improvement of self-control.

## 2. Methods

As the research is ongoing and we plan to present a new evaluation of the intervention in the future, some of the following descriptions of the research methods are provided in the present tense.

### 2.1. Study design

The study employs a quasi-experimental design in which trial participants are not allocated randomly to distinct treatment and comparison groups. Instead, they autonomously elect their group affiliations. Upon providing informed consent, patients choose to either engage in TAY classes or opt out. Self-reports through structured interviews serve as the mechanism for data collection and are conducted for both the yoga and comparison groups on two separate instances—prior to the commencement of the 10-week intervention period (pre-test) and subsequent to its completion (post-test).

During the 10-week timeframe, the group that does not practice TAY engages in typical physical activities—including walking, jogging, weightlifting, soccer, badminton, instructor-led group gym exercises, and spinning classes—for at least once a week, 50 min on each occasion. However, it is important to note that yoga is not part of the regular clinical care regimen for this group.

### 2.2. Standardized TAY classes

The TAY classes in the present intervention are meticulously adapted to address prevalent diagnoses within the context of forensic psychiatry. This adaptation ensures a safe yoga practice that is tailored to symptoms of traumatic stress, schizophrenia, psychosis, movement limitations, and side effects from antipsychotic medications, notably those affecting balance and coordination. In the current study, the TAY classes are held twice a week for 10 weeks, with a duration of 45 to 50 min each. The sessions feature a wide array of yoga techniques, encompassing physical movements, balance exercises, adapted breathing methods, and trauma-informed mindfulness guidance. This guidance is specifically intended to enhance interoceptive and present-moment awareness. Additionally, the sessions include brief periods of guided progressive muscle relaxation. To foster a sense of safety, predictability and control, the participants are organized in a semicircular formation. The instructional approach of TAY is distinguished by its trauma-informed nature, which includes an inviting demeanor, the provision of multiple options (A/B

choices), a time limit for challenging poses, and an emphasis on tangible physical sensations to enhance interoceptive awareness.

Participation in the classes is entirely voluntary, with a recommended group size of 8 to 10 patients and two yoga instructors per group. Individual and smaller group interventions are also permitted, specifically for patients with social anxiety/phobia or special needs. These tailored interventions are duly noted in the research protocol.

The chair-based yoga class included in the intervention was deliberately designed to be simple, clear, and user-friendly. It is well-suited for healthcare staff as instructors with no prior experience in yoga, and patients have the option to participate while seated, using the chair as support, or without the chair. This approach was meticulously crafted not only to minimize the risk of physical injuries but also to avoid the overstimulation of the sympathetic nervous system. It was designed to potentially increase heart rate variability by interspersing moments of stillness for pulse reduction with relaxation phases. Additionally, this strategy aims to assist participants in acquiring self-regulation skills.

The fidelity of the intervention is ensured through a predetermined structure, with specific lengths of time allocated for each segment of the class. This structured approach is consistent across all sessions, with each session adhering to a routine that follows a pre-recorded program provided during the instructor training. This methodical framework facilitates the standardization of the intervention, which is crucial for maintaining consistency and reliability in its delivery and, therefore, ensuring the integrity of the results. The yoga instructors document the participants' attendance and note any individual deviations from the established yoga protocol.

The components of each session are adaptable and include options that utilize chair support, either demonstrated with the aid of a chair or performed while seated, to ensure accessibility. The instructors provide verbal support and visual demonstrations to the participants. They also have the option to use digital support in the form of a recorded video. The instructors practice the yoga alongside the participants, offering various options to cater to individual needs throughout the classes.

The structure of each class is as follows:

- Warm-up exercises (10 min): In a seated position, the participants engage in chair-based warm-up exercises intended to promote blood circulation and proprioceptive awareness. These exercises feature gentle joint movements, side stretches, seated spinal movements, bilateral movements facilitating neural integration across the body's halves, and sensory integration through self-massaging of the hands and feet, enhancing spatial awareness. Movements targeting joint mobility and facial tension release are also incorporated to alleviate stress-related muscle strain.
- Dynamic movements (5 min): In this dynamic phase, participants engage in slow-paced, invigorating movements. These include expansive movements of the arms, shaking of the arms and legs, synchronized breathing, and coordinated movement to foster a collective rhythm. To heighten engagement, an emphasis is placed on voluntary breathing.
- Balance exercises (5 min): Focused on enhancing balance, this segment includes poses such as the tree, warrior 3 and modified, supported half crescent moon. These exercises are included to promote physical balance, concentration, and focus.
- Dynamic energizing movements and static positions (10 min): This ten-minute segment utilizes both dynamic, energy-boosting movements that synchronize movements with breathing (vinyasa) and static postures. Participants are encouraged to hold at least two dynamic postures for a minimum of one minute on each side. This practice aims to enhance impulse control and engage major muscle groups, with an additional focus on stretching the major hip-flexor group, particularly the psoas muscle. The incorporated yoga positions include the chair pose and warrior 1, with a variation of warrior 2.

- Final physical movements (10 min): This ten-minute period includes core-strengthening exercises, such as the boat position, performed seated on the floor or in a chair. It also involves the seated or reclined pigeon pose with accessible variations and twisting positions along with gentle neck and shoulder movements.
- Relaxed diaphragmatic breathing (3–5 min): To conclude the physical components of the session, a period of three to five minutes is allocated for voluntary relaxed diaphragmatic breathing. This segment involves the deliberate slowing of the breath, complemented by synchronized hand movements—especially beneficial for participants who need to move while focusing on their breathing. This practice is particularly emphasized during the first four weeks and subsequently included on an as-needed basis.
- Guided progressive muscle relaxation (5 min): Each session ends with a five-minute period of guided progressive muscle relaxation, allowing the participants to unwind and relax. Seated variations are demonstrated.

### 2.3. Qualifications of the yoga instructors

Instructors in the TAY program are required to be forensic psychiatric care providers and possess comprehensive training and experience relevant to these settings and the specific requirements of the patients. These instructors engage regularly in activities with the participants. They are of diverse professional backgrounds and include physiotherapists, occupational therapists, and healthcare personnel. Their diverse expertise is critical to meeting the unique needs of the patients and adhering to the security regulations of forensic psychiatric care facilities. Personal experience in yoga practice and leading physical activities is preferred but not mandatory.

#### 2.3.1. Training of the yoga instructors within forensic psychiatry

The training intervention was specifically designed to align with the specific needs of the forensic psychiatric clinics and the operational realities of the institutions. Those who designed the intervention considered the time constraints placed on staff during training, the feasibility of dedicating specific staff members to facilitate yoga within the clinics, and the budgetary limitations of forensic psychiatry settings. Supervision is provided for the yoga instructors for the entirety of the study.

The 60-hour foundational training program is divided into distinct segments. First is an initial introduction. Second is a one-month period in which yoga instructors engage in practicing the yoga program and familiarizing themselves with various yoga poses using a digital platform (12 h). Third is in-person training, which totals 30 h. Fourth is a three-month period dedicated to practicing and facilitating the yoga program, employing trauma-informed instruction and methodology (minimum 18 h). Fifth, each participant is required to record and submit a 15-minute video demonstrating the ability to facilitate parts of the yoga class using trauma-informed instruction and methodology. These videos are evaluated by the lead trainers. Additionally, the participants are required to complete a theoretical assessment before receiving their diploma for the foundational training (2 h). The sixth segment is the implementation of the yoga program with patients within the clinic. The instructors also have the option to practice the program using a filmed recording that includes modifications for common physical conditions, such as shoulder and back pain.

#### 2.3.2. The content of the training

The training content adheres to international guidelines for TIY and trauma-sensitive yoga trainings. It encompasses trauma theory, stress anatomy, knowledge of the autonomic nervous system and central nervous system as they relate to traumatic stress and psychiatric conditions, knowledge of common comorbid diagnoses and conditions, anatomy of yoga poses, anatomy of breath, nervous system regulation, safety measures for addressing common symptoms of traumatic stress,

and knowledge of the importance of establishing alliance, self-care and supervision.

Trauma-informed methodologies within TAY include the use of inviting language to foster non-coercion and a sense of autonomy and control; counting down in challenging poses for predictability and control; guiding practical interoceptive cues to clarify sensations in the body, thereby enhancing interoceptive awareness; providing choices of poses and practices to promote self-agency, safety, and increased self-care; trauma-informed room setup, ensuring that no participant is positioned directly behind another; adhering to the creation of a non-judgmental environment for fostering a sense of safety, predictability, and control; awareness of avoiding physical adjustments; knowledge of contraindications and precautions for PTSD and complex relational trauma; and a brief history, philosophy, and understanding of yoga.

Additional TAY contents tailored and adapted for psychiatric settings include awareness of triggers, trauma flashbacks and panic attacks and strategies for managing these in a yoga class; awareness of aggressive and psychotic behaviors; considerations of social structures within confined, correctional settings; the importance of clear instructions and routine for patients with psychosis; knowledge of contraindications and precautions for schizophrenia and psychosis; an understanding of the correlation between traumatic stress and substance use disorder; adaptations of the yoga practices to individual needs; the inclusion of practices for self-regulation and impulse control; strategies for conducting yoga in forensic psychiatric care; knowledge of beneficial practices to counteract side effects of common medications; methods for enhancing proprioception and concentration; adaptations for clinical settings and psychiatric care; the incorporation of adaptations for clinical staff experience and self-care; and programs for women's health.

Each approach shares key elements but is uniquely designed to cater to the specific needs of its target population and setting, with TAY offering a comprehensive approach that addresses the particular requirements of clinical settings and staff welfare.

### 2.3.3. Qualifications and competencies

The trained yoga instructors are qualified to teach the chair-based yoga program acquired during their training as well as simpler movements and breath-based exercises tailored to the individual needs of patients. The authorization to teach this program is limited to the forensic psychiatric environment, aligning with their professional roles, experiences, and education within this field. This qualification does not extend to teaching yoga to the general public outside their professional roles.

### 2.3.4. Trainers for the TAY program

The principal instructor, tasked with training TAY facilitators, is a licensed yoga therapist accredited by the Mindful Institute in London, a body recognized by the International Association of Yoga Therapists. The lead trainer, who is also an experienced yoga teacher trainer, possesses an Experienced Registered Yoga Teacher (E-RYT 500) license from the Yoga Alliance and a licensed Trauma Centre Trauma Sensitive Yoga Facilitator (TCTSY-F) certification. She is also a licensed facilitator accredited by the Yoga in Health Care Alliance, which focuses on yoga for the National Health Service in the United Kingdom. Her expertise in trauma includes her completion of the Certification Training in Traumatic Stress Studies at the Trauma Center in Boston, along with training undertaken for the Global Mental Health: Trauma and Recovery Certificate at Harvard Medical School. In addition, she holds the position of European Director of Programs for the Prison Yoga Project in Europe and played a pivotal role in co-developing the evidence-based "Krimyoga" program for the Swedish Prison and Probation Service. Her work extends to training prison and healthcare staff, and she has a cumulative experience of 18 years in correctional environments and psychiatric settings. She is the founder of Trauma-Adapted Yoga Sweden.

The TAY program utilized in the present intervention was collaboratively developed by the principal trainer, the co-trainer of the

intervention, the founder of Krimyoga, experts in trauma research, licensed physiotherapists who specialized in forensic psychiatric care, healthcare staff, and patients from Swedish clinics, and the international organization Prison Yoga Project.

The co-developer and lead trainer for the TAY program was the founder of Krimyoga. She obtained a yoga teacher diploma from the Kripalu Center for Yoga & Health in the United States. In addition, she holds a Master of Arts in the Study of Religions and Worldviews. With more than 30 years of yoga practice, she has dedicated the past two decades to training prison staff members to become yoga facilitators.

## 2.4. Study population

Participants are required to meet certain criteria to be included in the study. They must have been hospitalized for a minimum of two months to ensure that their diagnoses and medication regimens are as stable as possible. Patients with significant physical ailments that hinder participation in yoga classes are excluded from the study. The survey, administered as a structured interview, is available in four languages (Swedish, English, Dari, and Arabic) to enhance accessibility. However, in the current dataset, only Swedish responses were received. The structured interviews are carried out by the clinic's site managers, usually psychologists, and span a duration of 2 to 5 days, adjusted based on each participant's ability to concentrate during questioning. Care personnel read the questions to the participants and are explicitly instructed not to offer comments or influence the answers. These self-report questionnaires are administered as structured interviews to ensure that patients remain attentive and do not inadvertently skip any questions.

The present analysis encompasses data from 56 participants from 6 of the 10 participating clinics, with participant numbers ranging from 5 to 15 patients in each clinic.

## 2.5. Measures

The structured interviews encompass six validated measures, described below.

### 2.5.1. The forensic psychiatry version of the prison adjusted measure of aggression interview

The Prison Adjusted Measure of Aggression (PAMA) evaluates the self-reported frequencies of aggressive and antisocial behaviors within correctional settings over the prior month (Kerekes et al., 2018). The PAMA comprises 11 items categorized into three subscales: a 5-item aggression scale, a 4-item antisocial behavior scale, and a 2-item self-directed aggression scale. The aggression subscale gauges overt aggression and encompasses items like temper tantrums, verbal and indirect aggression, non-specific fighting, and physical assault against individuals. The antisocial behavior subscale includes items related to disciplinary issues, conflicts with authority, and antisocial actions leading to punitive outcomes. The self-directed aggression subscale covers items concerning self-injurious behavior and suicide attempts.

Each item is rated on a six-point scale according to the total number of occurrences in the preceding month: no occurrences (0), one event (1), two or three events (2), four to nine events (3), ten or more events (4), or more events than can be counted (5). The total PAMA score is the cumulative sum of all 11 item ratings and ranges from 0 to 55. The scores on specific items within a particular subscale form the score for that subscale. The aggression subscale score ranges from 0 to 25, the antisocial behavior subscale score from 0 to 20, and the self-directed aggression subscale score from 0 to 10.

Previous research has established the acceptable validity of the PAMA (Kerekes et al., 2018). In the present study, its internal reliability is not acceptable (Cronbach's alpha, 0.41).



### 2.5.2. Positive and negative affect schedule—expanded form, 30 items

The Positive and Negative Affect Schedule—Expanded Form, 30 items (PANAS-X30) is an instrument designed to evaluate both positive affect (PA) and negative affect (NA) (Watson et al., 2018). In recent research, these two overarching emotional dimensions have emerged as significant factors in emotional experiences. These factors have demonstrated consistency across intra- and inter-individual analyses, maintaining their relevance across diverse descriptors, temporal frames, languages, and cultures (Oishi et al., 2004).

In contrast to the original PANAS, which offers two 10-item scales for PA and NA, the PANAS-X30 features a comprehensive 30-item structure. This expanded framework offers dual levels of mood measurement, valence (PA and NA) and content (distinct qualities of individual affects [i.e., “high arousal” or “low arousal”]) (Russel, 1980). This expanded perspective enables the measurement of pleasant and unpleasant states as well as the intensity of high- and low-arousal emotional experiences.

The reliability of the four scales (high and low arousal PA and high and low arousal NA) demonstrates acceptable internal consistency, with Cronbach’s alphas ranging from 0.77 to 0.88 (Kerekes et al., 2017). In the present study, these values are between 0.66 and 0.90.

### 2.5.3. Brief symptom inventory

Derived from the System Checklist-90-Revised, the Brief Symptom Inventory (BSI) serves as a suitable measure for general psychopathology and psychological distress (Morlan and Tan, 1998). Comprising 53 items, the BSI captures psychological symptom patterns exhibited by psychiatric and medical patients and non-patients. The scale incorporates nine symptom scales and a global severity index (GSI). Participants provide their responses on a five-point scale ranging from 0 (“not at all”) to 4 (“extremely”).

The BSI demonstrates high internal consistency (Cronbach’s alpha: 0.71–0.85) and test-retest reliability and noteworthy convergent, discriminant, and construct validity (Derogatis and Melisaratos, 1983). In the present study, the Cronbach’s alphas range from 0.75 to 0.86 for the primary domains and the GSI.

### 2.5.4. Brief substance craving scale

The Brief Substance Craving Scale, devised by Somoza et al. (1995), uses a four-item assessment to gauge a participant’s intensity, frequency, and duration of cravings. This concise self-report measure has been previously utilized and subjected to rigorous psychometric assessment (Elkashaf et al., 2005; Adler et al., 2010). In the present study, its internal reliability is acceptable (Cronbach’s alpha, 0.94).

### 2.5.5. Pain assessment instruments

In accordance with the guidelines of the Swedish healthcare system, the pain assessment instruments employ verbal and numerical assessment scales. Participants convey their pain experiences over the preceding two weeks using both descriptive words (no pain, mild pain, moderate pain, severe pain, very severe pain, or unbearable pain) and numerical values ranging from 0 to 10. The numerical scale uses 0 to signify no pain and 10 to denote the utmost discomfort. Additionally, participants have the opportunity to indicate the location and type of pain on a standard anatomical image of an adult (Vårdhandboken).

### 2.5.6. Self-directedness

Self-directedness, a personality trait linked with self-determination, denotes the ability to regulate and adapt behavior to fulfill personally chosen objectives and values. This trait constitutes one of the character dimensions outlined in Cloninger’s Temperament and Character Inventory (TCI) (Cloninger et al., 1993). Cloninger characterizes it as “willpower,” indicating the extent to which an individual perceives themselves as a cohesive and purposeful entity rather than a collection of unorganized reactive impulses.

There are validated Swedish adaptations of the TCI (Brändström et al., 2008) and TCI-Revised (Brändström et al., 2003). A subset of 20

questions comprising the self-directedness scale was extracted from the TCI-Revised, and only these questions were utilized. In the present study, the internal reliability of these 20 items is acceptable (Cronbach’s alpha, 0.85).

### 2.6. Register data

Register data concerning the diagnoses at the start of the study and changes in the participants’ medications during the study are assessed by the site managers using clinical journals.

### 2.7. Ethical considerations

The present study has undergone rigorous oversight and received approval from the Swedish National Ethical Board (registration number 2021-01533, assigned in 2021). Due to the COVID-19 pandemic, the project timeline extended beyond the initial deadline, prompting the submission of a request for a study extension to the ethical board. This new application was granted approval (registration number 2023-03408-02).

Our study adheres to the fundamental principles outlined in the Helsinki Declaration and aligns with the criteria established by the European Union’s General Data Protection Regulation (GDPR) as well as the Swedish legislation governing personal health care information. Participation in the study is voluntary and does not impact the participants’ overall care at the forensic psychiatry clinics.

All data collection is meticulously conducted, and all data are securely stored in coded format at the clinics. Only encoded research data are transferred to University West. This approach ensures the confidentiality and privacy of the participants while upholding the highest ethical standards.

### 2.8. Statistical methods

Only complete post-attrition data from participants who have attended a minimum of 10 yoga classes within the 10-week intervention period are subjected to analysis. All statistical analyses are carried out with a significance level of  $\alpha < 0.05$ . Because the Shapiro-Wilk test for normality revealed significant deviations from a normal distribution for several scales, and considering the small sample size, only non-parametric tests were used for analysis. To assess changes within groups, the Wilcoxon signed-rank test is used to compare the pre- and post-test scores. To identify these changes within the groups, mean (M) values and standard deviations (SDs) are computed. Changes between groups are analyzed using the Mann-Whitney U test, and the effect size ( $\eta^2$ ) is calculated using the following equation:  $\eta^2 = Z^2/(N-1)$ . An  $\eta^2$  value between 0.01 and 0.059 indicates a small effect size, a value between 0.06 and 0.13 indicates a medium effect size, and a value exceeding 0.14 indicates a large effect size (Adams and Conway, 2021).

## 3. Results

### 3.1. Study population and attrition rate

Over the course of approximately one year of data collection across six out of the 10 participating clinics, data were obtained from a total of 56 patients (37 in the yoga group and 19 in the comparison group). Notably, the attrition rate was low, with only seven patients (12.5 %) discontinuing participation prematurely. Of these patients, six were from the yoga group, resulting in a 16 % attrition rate within that group. The reasons cited for dropping out included a loss of motivation to continue (two patients), a lack of affinity for yoga (two patients), and a general sense of discomfort (one patient) and being transferred to another clinic (one patient from the yoga group and the one from the comparison group). Table 1 provides a summary of the gender and age distributions and the average number of diagnoses in the yoga,

**Table 1**

Descriptive information about the participants in the yoga, comparison and dropout groups.

	Yoga Group	Comparison Group	Dropouts
<b>N</b>	31	18	7
(male / female)	(29 / 2)	(10 / 8)	(6 / 1)
<b>Age, Md</b>	32	32	28
<b>M (SD)</b>	35.3 (10.58)	38.26 (14.28)	32.43 (13.61)
<b>Number of diagnoses, Md / M</b>	2 / 1.87	2 / 2.39	2 / 2.86

M=Mean value; Md= Median value; SD= Standard deviation

comparison and dropout groups.

The age distribution of the patients was comparable among these groups, albeit slightly younger among those who dropped out of the study. Additionally, the average number of diagnoses was consistent across these three groups. Table 2 provides an overview of the prevalence rates of various diagnoses within the yoga, comparison and dropout groups.

Of the 49 participants who successfully completed the 10-week study, 10 (20 %) were women. Regrettably, a notable 80 % of the female patients opted not to partake in yoga classes, leading to a pronounced gender imbalance favoring women within the comparison group. Consequently, a decision was made to exclusively analyze data from male patients in this study (Fig. 1).

Of these 39 male patients, 30 fulfilled the inclusion criteria by either participating in a minimum of 10 yoga sessions or engaging in at least 10 instances of physical activity during the study period. Of these 30, nine individuals were part of the comparison group, while the remaining 21 chose to be in the yoga group (Fig. 1).

### 3.2. Within- and between-group analyses

For the yoga group, several positive changes were found during the 10-week intervention. The numbers of aggressive, self-harm, and anti-social behaviors measured by the PAMA instrument decreased, but none of these decreases reached significance. The decrease in the total PAMA score approached significance ( $p = 0.07$ ) (Table 3). Similar changes were recorded for the comparison group, though none of them reached or approached significance (Table 3).

With regard to emotional states, there were significant, large decreases in negative affect (including both high [ $p = 0.006$ ;  $\eta^2 = 0.38$ ] and low arousal [ $p = 0.009$ ;  $\eta^2 = 0.34$ ] subscales) in the yoga group (Table 3, Fig. 2). There was no significant change to positive affect in the yoga group, and there were no significant changes to positive or

**Table 2**

Prevalence rates of different psychiatric diagnoses within the yoga, comparison, and dropout groups.

	Yoga Group	Comparison Group	Dropouts
ADHD	3 %	11 %	29 %
Anxiety	6 %	0 %	29 %
ASD	16 %	11 %	29 %
Cognitive impairments	10 %	6 %	14 %
Depression	3 %	11 %	0 %
Other (brain damage, chromosome disorder, sexual behavior disorder, other)	6 %	33 %	43 %
Other psychotic disorders	23 %	17 %	29 %
Personality disorder	16 %	78 %	14 %
Schizophrenia	55 %	44 %	57 %
Substance use-related syndrome	48 %	56 %	43 %

ADHD= Attention Deficit/Hyperactivity Disorder; ASD= Autism Spectrum Disorder

negative affect in the comparison group (Table 3).

Changes in the levels of psychological distress were assessed using the nine domains of the BSI and its GSI score.

Table 4 illustrates the changes in the both groups' levels of psychological distress before and after the intervention.

Within the yoga group, a consistently improved mental health profile was observed, characterized by reduced psychological distress across all domains and GSI scales. Notably, several of these changes reached the level of statistical significance and exhibited large effect sizes; these changes included decreases in anxiety, interpersonal sensitivity, hostility, paranoid ideations, phobic anxiety, and even the GSI (Fig. 3). There was a reduction in obsessive-compulsive thoughts that approached statistical significance ( $p = 0.05$ ).

Within the comparison group, although decreases in psychological distress were observed in several (not all) primary domains, none of these changes reached or approached statistical significance (Table 4, Fig. 3).

The intensity of the participants' pain decreased in the yoga group ( $M [SD] = 2.33 [3.15]$  to  $1.45 [2.82]$ ;  $p = 0.21$ ) and increased in the comparison group ( $1.89 [2.03]$  to  $2.88 [3.14]$ ;  $p = 0.40$ ). However, neither of these changes reached significance. The frequency of pain decreased significantly in the yoga group ( $1.10 [1.48]$  to  $0.57 [1.03]$ ;  $p = 0.04$ ) with a large effect size ( $\eta^2 = 0.21$ ); it showed a small and non-significant decrease in the comparison group ( $1.33 [1.41]$  to  $1.22 [1.56]$ ;  $p = 0.78$ ).

Both groups demonstrated decreases in the intensity, duration, and frequency of cravings, but none of these changes approached statistical significance (Table 5).

Lastly, the yoga group showed a statistically significant change ( $p = 0.03$ ,  $\eta^2 = 0.24$ ) in the assessment of character maturity within the self-directedness domain, representing a large effect (Table 6). This occurred despite a smaller average increase (potentially due to lower variability and a sufficient sample size to detect this change).

The between-group analyses did not yield any statistically significant differences between the yoga and comparison groups with the exception of pain intensity ( $p = 0.02$ ); over the 10 weeks of the study, the comparison group demonstrated an increase while the yoga group demonstrated a decrease.

### 3.3. Changes in medication

Changes in medication were reported by a mere four participants in the yoga group (19 %) and one individual in the comparison group (11 %). This limited reporting underscores the significant challenge of relying on adjustments in medication to control for its potential influence on measured changes in behavior and psychological functioning. The changes in medication within the yoga group encompassed various adjustments, including an increase in sedative dosage, the initiation or increase of neuroleptic medication, a reduction in stimulants, and the utilization of other medicines (e.g., for diabetes or rheumatoid disease).

## 4. Discussion

This study provides the analysis of a quasi-experimental investigation into the effects of a 10-week TAY program for forensic psychiatry, implemented across multiple forensic psychiatric clinics in Sweden. Notably, this is the first comprehensive presentation of the structured TAY program. Our detailed presentation of TAY follows the CLARIFY-21 (CheckList Standardising the Reporting of Interventions For Yoga) Delphi-based guidelines, which were designed to ensure comprehensive and transparent reporting in yoga research, as outlined by Moonaz et al. in 2021. These guidelines cover various aspects of reporting; the points that pertain to home practice and protocol changes are not included, as they are not relevant to the scope of this study.

The structured TAY classes encompass a carefully curated fusion of yoga techniques, incorporating physical movement, sensory integration,

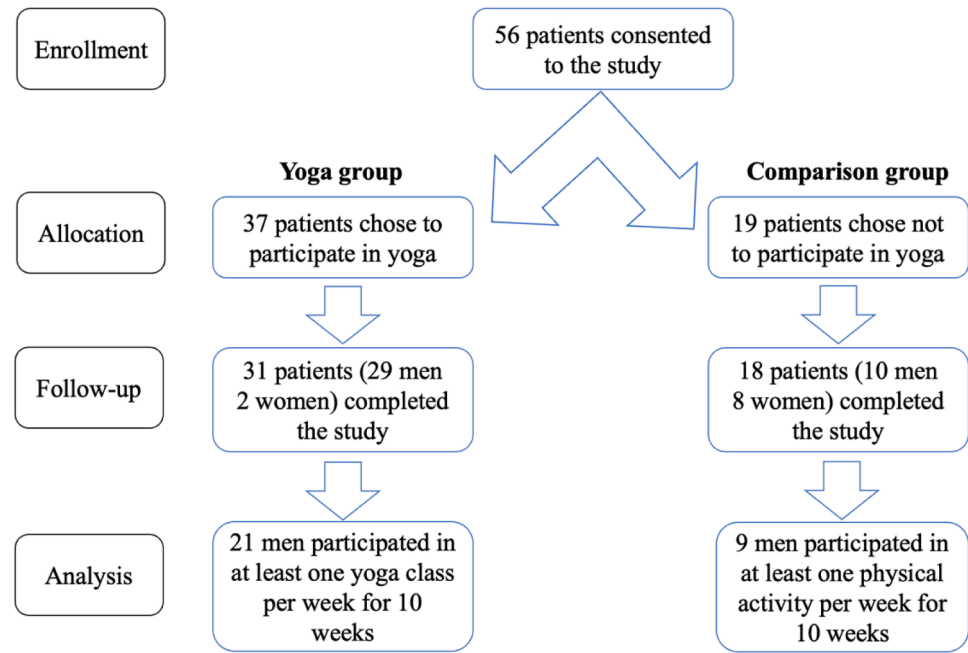


Fig. 1. An adapted CONSORT (Consolidated Standards of Reporting Trials) diagram for the quasi-experimental study.

**Table 3**  
The levels of aggressive antisocial behaviors and emotional states within the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

	Pre-intervention M (SD)		Post-intervention M (SD)		p	$\eta^2$ *
	Yoga	Compari-son	Yoga	Compari-son		
PAMA-aggression	0.38 (0.92)	0.33 (0.71)	0.05 (0.22)	0.0 (0)	0.10 / 0.18	- / -
PAMA- self-harm	0.10 (0.30)	0.11 (0.33)	0.0 (0)	0.0 (0)	0.16 / 0.32	- / -
PAMA- antisocial behaviors	0.43 (1.16)	0.33 (1.00)	0.24 (0.89)	0.0 (0)	0.68 / 0.32	- / -
PAMA- total	0.90 (1.73)	0.78 (1.70)	0.29 (0.90)	0.0 (0)	0.07 / 0.10	- / -
Positive high arousal affects	27.81 (8.28)	32.11 (7.08)	26.85 (8.67)	27.11 (5.80)	0.49 / 0.21	- / -
Positive low arousal affects	15.29 (4.62)	15.44 (4.90)	15.05 (4.15)	15.11 (4.49)	0.89 / 0.86	- / -
Positive affect states	43.10 (11.77)	47.56 (11.50)	41.77 (11.97)	42.22 (10.01)	0.71 / 0.40	- / -
Negative high arousal affects	18.00 (8.39)	14.67 (3.57)	14.29 (3.65)	14.78 (3.31)	0.006 / 0.94	0.38 / -
Negative low arousal affects	12.91 (3.95)	10.44 (3.61)	10.05 (3.46)	10.78 (2.39)	0.009 / 0.73	0.34 / -
Negative affect states	30.91 (11.57)	25.11 (5.13)	24.33 (6.61)	25.56 (5.05)	0.006 / 0.76	0.38 / -

\*  $\eta^2$  is calculated only for significant within-group changes.; M=Mean value; SD= Standard deviation

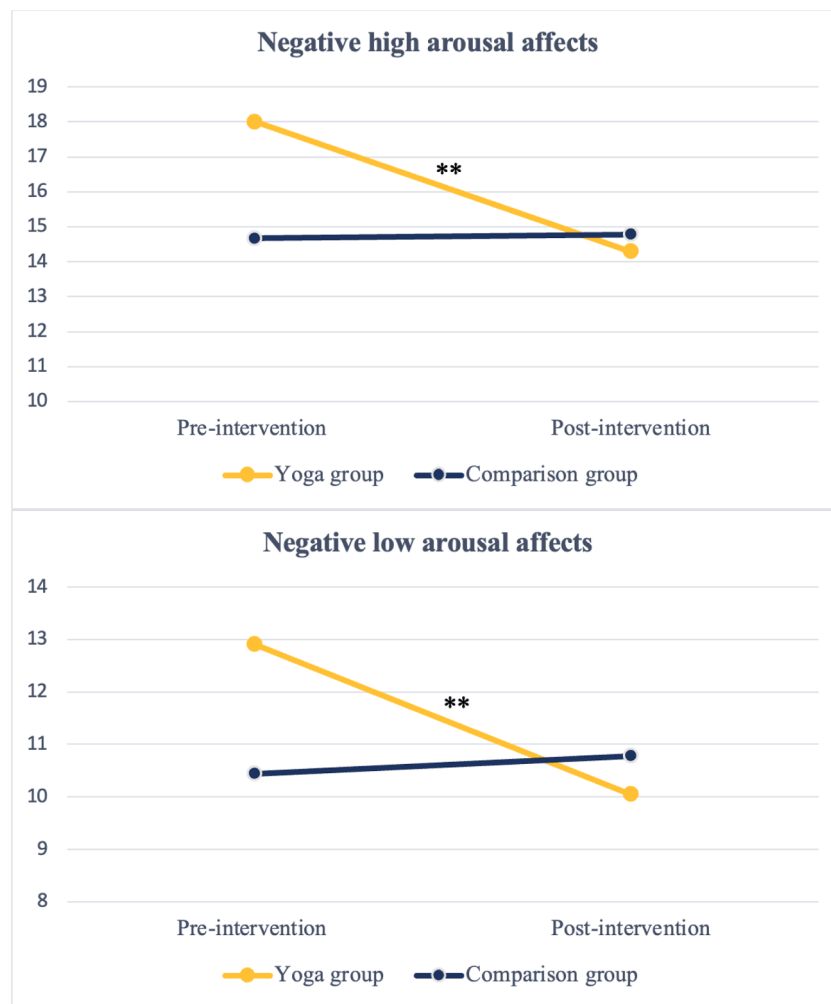
balance exercises, focused breathing, practical mindfulness guidance, and brief guided relaxation. The classes aim to equip the participants with self-regulation tools applicable to their daily lives. Importantly, these sessions do not include activities that could potentially overstimulate the sympathetic nervous system, nor do they involve physical adjustments or touch from the yoga instructors.

The comprehensive description of TAY encompasses an examination of its similarities and differences in comparison to TIY and trauma-sensitive yoga trainings. This thorough presentation of TAY is in line with the highest standards of reporting, laying a robust groundwork for the comprehension and replication of the program within forensic psychiatry settings.

The question of why to test TAY in a population in which an absence of PTSD diagnoses was reported is indeed relevant. Numerous studies

have shown that a significant proportion of patients in forensic psychiatry have experienced childhood or lifetime trauma (Kristiansson et al., 2004; Garieballa et al., 2006, Bianchini et al., 2022). However, it is important to note that diagnosing PTSD may not be a routine part of forensic clinical practice. While trauma is widely recognized as one of the strongest risk factors for the development of psychiatric disorders, the absence of specific PTSD diagnoses within this population raises questions about the extent to which trauma-related issues are addressed within forensic psychiatry settings. This study’s focus on TAY provides valuable insights into the potential benefits of a trauma-adapted intervention, even in the absence of formal PTSD diagnoses, highlighting the broader applicability of such interventions in forensic psychiatric care.

A recent program evaluation of TIY (akin to TAY) yielded compelling results regarding its feasibility and efficacy within institutional settings



**Fig. 2.** The levels of negative high and low arousal emotional states within the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

**Table 4**

The levels of psychological distress (as expressed by nine Brief Symptom Inventory domains and the Global Severity Index) in the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

	Pre-intervention M (SD)		Post-intervention M (SD)		<i>p</i>	$\eta^2$ *
	Yoga	Comparison	Yoga	Comparison		
<b>Anxiety</b>	1.01 (0.81)	1.00 (0.79)	0.42 (0.48)	0.78 (0.66)	<b>0.002</b> / 0.08	0.47 / -
<b>Depression</b>	0.87 (0.82)	0.85 (0.79)	0.68 (0.72)	0.59 (0.68)	0.08 / 0.17	- / -
<b>Hostility</b>	0.44 (0.56)	0.31 (0.66)	0.20 (0.30)	0.24 (0.48)	<b>0.044</b> / 0.32	0.20 / -
<b>Interpersonal Sensitivities</b>	0.62 (0.82)	0.56 (0.53)	0.30 (0.38)	0.64 (0.67)	<b>0.047</b> / 0.68	0.20 / -
<b>Obsessive-compulsive thoughts</b>	1.08 (0.94)	0.74 (0.58)	0.83 (0.76)	0.52 (0.42)	0.05 / 0.20	- / -
<b>Paranoid thoughts</b>	0.65 (0.74)	0.64 (0.90)	0.37 (0.37)	0.64 (0.79)	<b>0.035</b> / 1.00	0.22 / -
<b>Psychotic symptoms</b>	0.66 (0.80)	0.53 (0.62)	0.39 (0.39)	0.47 (0.52)	0.08 / 0.45	- / -
<b>Phobic anxiety</b>	0.42 (0.54)	0.44 (0.58)	0.14 (0.20)	0.42 (0.74)	<b>0.011</b> / 0.92	0.33 / -
<b>Somatization</b>	0.47 (0.52)	0.44 (0.44)	0.36 (0.42)	0.39 (0.26)	0.38 / 0.92	- / -
<b>Global Severity Index</b>	0.70 (0.58)	0.61 (0.46)	0.52 (0.38)	0.57 (0.44)	<b>0.013</b> / 0.29	0.31 / -

\*  $\eta^2$  is calculated only for significant within-group changes.; M=Mean value; SD= Standard deviation; Bold font labels statistical significance





**Fig. 3.** Scores for the Brief Symptom Inventory domains of anxiety, hostility, interpersonal sensitivity, paranoid thoughts, and phobic anxiety, and Global Severity Index scores for the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

(Tibbitts et al., 2021). Notably, participants within the corrections and reentry contexts demonstrated significant improvements, including decreased stress and anxiety levels, enhanced emotional regulation, heightened tolerance of distress, improved self-confidence, enhanced impulse control, augmented self-compassion, and increased compassion for others. Additionally, discernible benefits were observed in terms of reduced pain, improved sleep quality, and enhanced physical conditioning (Tibbitts et al., 2021). Similarly, prior studies reported improvements in anxiety and depression symptoms among psychiatric populations (Nyer et al., 2018).

Consistent with these findings, our study reveals that a 10-week TAY intervention within forensic psychiatric clinics yields substantial positive changes. These significant changes, present within the yoga group but not the comparison group, exhibit large effect sizes and manifest as reduced negative affect states; reduced symptoms across primary domains of anxiety, phobic anxiety, obsessive-compulsive thoughts, paranoid ideations, interpersonal sensitivity, and hostility; and a noteworthy reduction in overall psychological distress (GSI). Furthermore, in this study, the yoga group exclusively demonstrated a significant reduction in pain frequency.

Our study demonstrates that participants who engage in TAY practices experience significant enhancement in the self-directedness domain of personality. However, this is not true of those receiving

care as usual and engaging in physical activity equivalent in frequency and duration to the TAY classes. This relevance of the self-directedness domain within our study population stems from previous findings that have indicated a strong association between the presence of psychiatric disorders (e.g., personality disorders, autism spectrum disorder, attention deficit/hyperactivity disorder, behavioral disorders, and even trait aggression in inmates) and immature character maturity, characterized by low self-directedness (and low cooperativeness) (Richter and Brändström, 2009; Nilsson et al., 2016; Vuijk et al., 2018; Perroud et al., 2016; Flak et al., 2017). Importantly, a previous study identified significant increases in self-directedness among inmates who engaged in yoga practice (Kerekes et al., 2019). Enhanced self-directedness encompasses a stronger sense of self-agency, improved self-control (including emotional and behavioral regulation), and an increased capacity for taking responsibility (Cloninger et al., 1993).

The mechanisms underlying the observed changes related to yoga practice are hypothesized to operate at multiple levels—neuroanatomical, neurochemical, and physiological—leading to consequential psychological and behavioral shifts. A comprehensive Cochrane systematic review by Broderick et al. (2018) provided an insightful panorama of the effects and safety of yoga for individuals with schizophrenia. This review is especially relevant to our study given the prominence of schizophrenia diagnoses in forensic psychiatry. The review delved into potential

**Table 5**

The Brief Substance Craving Scale item scores for the participants in the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

	Pre-intervention M (SD)		Post-intervention M (SD)		<i>p</i>
	Yoga	Comparison	Yoga	Comparison	
<b>Intensity of cravings</b> (Likert- scale between 0 and 4)	0.76 (1.25)	0.63 (1.04)	0.44 (1.15)	0.38 (0.74)	0.35 / 0.32
<b>Frequency of cravings</b> (Likert- scale between 0 and 4)	0.76 (1.57)	0.88 (1.46)	0.44 (1.15)	0.50 (0.76)	0.13 / 0.41
<b>Lengths of cravings</b> (Likert- scale between 0 and 4)	0.59 (1.12)	0.63 (1.41)	0.33 (0.97)	0.50 (0.76)	0.16 / 1.0
<b>Number of cravings during the prior 24 h</b>	0.69 (1.18)	1.0 (1.63)	0.53 (2.07)	1.0 (1.61)	0.49 / 0.16

M=Mean value; SD= Standard deviation

mechanisms through which yoga exerted its influence on this specific clinical population. The authors proposed that yoga may modulate the autonomic nervous system, impacting the limbic system and the hypothalamic–pituitary–adrenal axis. This regulation may result in decreased blood cortisol levels, contributing to reductions in stress and negative affect states. Moreover, consistent yoga practice among individuals with schizophrenia was associated with elevated oxytocin levels, contributing to improved mood. Additionally, heightened levels of the neurotransmitter gamma-aminobutyric acid may facilitate enhanced impulse control and emotional regulation (Broderick et al., 2018). Other studies have shown that yoga practice is associated with increased levels of glutamate and brain-derived neurotrophic factor, which expedite neuroplasticity—the brain's ability to change, reorganize, and build new neural networks (Nourollahimoghadam et al., 2021). Neuroanatomical changes in yoga practitioners include augmented gray matter volume in regions such as the insula and hippocampus, which are linked to pain processing, learning, and memory. Increased activation of prefrontal cortical areas, which can enhance self-regulation—encompassing both emotional and behavioral domains—have also been noted. Furthermore, alterations in functional connectivity, primarily within the default mode network, may comprise the physiological reason for improvements in attention and neurocognitive functions (van Aalst et al., 2020). These proposed mechanisms offer a multi-dimensional understanding of the effects of yoga practice, shedding light on the intricate interplay between physiological, neurochemical, and psychological processes.

The attrition rate within the yoga group in the present study was 16 %, which is notably lower than previously documented rates within correctional settings (32.7 %; Kerekes et al., 2017). This underscores the

feasibility of implementing this intervention within the context of forensic psychiatry settings. Although the primary focus of the present study was not to assess feasibility, this determination emerged as a valuable byproduct. Presently, there are additional forensic psychiatry units in Sweden equipped with competent caregivers capable of providing TAY to patients, more than the 10 included in this study. While not all of these units chose to participate in our study, they continue to implement this complementary care. Following the conclusion of this study we will advance our data collection efforts and aim to complete our analyses with qualitative interviews with patients and caregivers. Additionally, we may consider conducting gender-specific analyses in the future, if data allow that. Through future studies, we endeavor to offer comprehensive evidence of the feasibility and impact of TAY in the realm of forensic psychiatry care.

## 5. Strengths and limitations

One notable limitation of this study is the small size of the comparison group. Despite this constraint, we find it imperative to publish these analyses. They have successfully demonstrated significant, positive, medium and large changes specifically attributed to the practice of TAY within forensic psychiatry settings.

Another limitation pertains to the scarcity of information regarding medication changes during the study period. We discovered that obtaining such data can be challenging and may yield unreliable information, particularly within a patient group that relies heavily on medication. Consequently, tracking changes in medication over a relatively short study period, as was the case in our research, did not provide relevant information in the current context. The same can be said for the assessment of cravings; given the high levels of medication among the study population, cravings do not constitute a relevant measure of the well-being of the participants. Furthermore, the low frequency of reported aggressive and antisocial behaviors (or, in several cases, the absence thereof) and the low internal consistency of the measure raises questions about the relevance of the PAMA instrument for detecting these aspects within forensic psychiatry settings. In the present study, the demographic descriptors of the population were limited to age, psychiatric diagnoses, and gender. However, it is important to acknowledge the potential limitations in generalizability due to the absence of other demographic variables, such as ethnicity, educational level, and forensic history.

One significant limitation of the study pertains to its quasi-experimental design. We believe that allowing patients the choice to participate in yoga classes was necessary to gather a sufficient amount of data for the statistical analysis. While a full randomized controlled trial design would provide the highest level of evidence, randomizing some participants who were interested in trying yoga into a waiting list would likely have resulted in the loss of participants.

This brings us to the strengths of the study. The most notable is its design, which incorporates a comparison group. It represents the first study that endeavors to provide scientific evidence regarding the specific impact of TAY (compared to that of standard physical activity) on the behavior, mental health, and character development of incarcerated individuals with severe mental diagnoses.

**Table 6**

Mean values on the self-directedness domain of the Temperament and Character Inventory within the yoga and comparison groups before (pre-intervention) and after (post-intervention) 10 weeks of the TAY intervention.

	Pre-intervention M (SD)		Post-intervention M (SD)		<i>p</i>	$\eta^2$ *
	Yoga	Comparison	Yoga	Comparison		
<b>Self-directedness</b>	77.62 (11.31)	74.63 (11.95)	80.81 (13.37)	81.75 (13.00)	<b>0.03</b> / 0.21	0.24 / -

M=Mean value; SD= Standard deviation; Bold font labels statistical significance

## 6. Conclusion

The analyses of this quasi-experimental study demonstrate the feasibility of implementing TAY within forensic psychiatry clinics. The patients' engagement with the intervention is also an encouraging sign of its acceptability. Offering TAY within forensic settings has potential benefits, including improved mental health and pain management for patients, based on this study's results. However, TAY programs may also present challenges, such as the need for trained instructors, time constraints within clinical settings, and potential variations in patient responses. Exploring these pros and cons in future research can help refine the implementation of TAY in forensic psychiatry. Although the distinctions between the yoga and comparison groups did not attain statistical significance in the present study, the outcomes hold promise and serve as an encouraging impetus to persist in data collection and reevaluate the results with a larger participant cohort.

## CRedit authorship contribution statement

**Nora Kerekes:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing.

## Declaration of competing interest

In accordance with ethical guidelines, the author declares that there are no competing interests related to the research, publication, or any other aspects of this scientific article.

## Data availability

At the present stage of the study, data are not available for data share.

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