Journal of Psychiatric Research 201 (2026) 149–162

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

The state urge to be physically active in anorexia nervosa: a systematic review of mechanisms and clinical implications

Margherita Boltri [a,b,c,*], Carolina Gabutti [a], Lara Pignattai [a,d], Federico Brusa [a,e], Emanuela Apicella [a], Gianluca Castelnuovo [b,f], Walter Sapuppo [d], Leonardo Mendolicchio [a,e], Mouna Hanachi [g,h], Johannes Hebebrand [i,j], Georgios Paslakis [k]

[a] I.R.C.C.S. Istituto Auxologico Italiano, Experimental Laboratory for Metabolic Neurosciences Research, Piancavallo, VCO, 28824, Italy
[b] Psychology Department, Università Cattolica del Sacro Cuore, Milan, Italy
[c] Doctoral School n° 569 ITFA - Innovation thérapeutique: du fondamental à l'appliqué, Université Paris-Saclay, France
[d] Department of Psychology, Sigmund Freud University, Milan, Italy
[e] I.R.C.C.S. Istituto Auxologico Italiano, U.O.C. dei Disturbi dell'Alimentazione e della Nutrizione, Ospedale San Giuseppe, Piancavallo, VCO, Italy
[f] I.R.C.C.S. Istituto Auxologico Italiano, Laboratorio di Psicologia, Ospedale San Giuseppe, Piancavallo, VCO, Italy
[g] Clinical Nutrition Department, AP-HP Hôpital Paul-Brousse, University of Paris-Saclay, Villejuif, France
[h] INRAE, AgroParisTech, MICALIS Institute, Université Paris-Saclay, Jouy-en-Josas, France
[i] Department of Child and Adolescent Psychiatry, Psychotherapy and Psychosomatics, University Hospital Essen (AöR), University of Duisburg-Essen, Essen, Germany
[j] Center for Translational Neuro- and Behavioral Sciences, University Hospital Essen, University of Duisburg-Essen, Essen, Germany
[k] University Clinic for Psychosomatic Medicine and Psychotherapy, Medical Faculty, Campus East-Westphalia, Ruhr-University Bochum, Luebbecke, Germany

ARTICLE INFO

Keywords:
Anorexia nervosa
Eating disorders
State urge to be physically active
Physical activity
Urge to move

ABSTRACT

Objective: Anorexia nervosa (AN) is a severe eating disorder, leading to life-threatening complications and psychosocial impairment. Among its complex clinical features, a prominent but poorly understood feature is the intense State Urge to be Physically Active (SUPA), which may not always manifest as observable physical activity. This systematic review followed PRISMA guidelines to synthesize current empirical evidence regarding the characteristics, biological underpinnings, assessment methods and clinical implications of SUPA in AN across varying illness severity levels.

Methods: A systematic search of PubMed, Scopus, and EBSCOhost databases identified 1165 records, of which 17 studies met the inclusion criteria and were included in the final review. These studies employed both objective and subjective assessments of the SUPA.

Results: Findings suggest that the SUPA may persist regardless of BMI changes, including during recovery, and may function as a maladaptive emotion regulation strategy, rather than reflect a dispositional feature. Higher SUPA levels during weight restoration seem to predict poorer post treatment weight maintenance.

Discussion: In clinical settings, SUPA may signal illness severity and resistance to weight restoration, warranting its proactive inclusion in diagnostic and treatment frameworks. To advance understanding and management of SUPA in AN, future research should address confounding factors such as illness duration, validate standardised assessment tools and procedures, and explore targeted interventions to improve outcomes in AN.

1. Introduction

Anorexia Nervosa (AN) (American Psychiatric Association, 2022) is a severe eating disorder characterised by low body weight, caloric restriction, and behaviors that increase energy expenditure (e.g., increased physical activity) (Moskowitz and Weiselberg, 2017). It is marked by an intense fear of gaining weight, persisting even after significant weight loss (Weiss Roberts et al., 2017), and a strong preoccupation with weight and body shape. The disorder is also associated with an inability to recognise the severity of the condition (Neale and Hudson, 2020). Beyond these features, a clinically relevant but often overlooked aspect of the AN phenotype is the paradoxical experience of heightened physical and mental energy, despite severe caloric restriction and low body weight (Casper, 2016). Historically, research on

* Corresponding author. Psychology Department, Università Cattolica del Sacro Cuore, Milan, Italy
E-mail address: margherita.boltri@unicatt.it (M. Boltri).

https://doi.org/10.1016/j.jpsychires.2026.06.022
Received 23 January 2026; Received in revised form 12 May 2026; Accepted 12 June 2026
Available online 13 June 2026
0022-3956/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

starvation responses (Aspen, 1993; Keys et al., 1952) has demonstrated that prolonged dietary restriction typically leads to decreased physical activity, inertia, and apathy. However, some studies have also reported psychological responses such as inner restlessness and nervousness (Keys et al., 1952), which might parallel the paradoxical drive for activity seen in individuals with AN (Casper, 2006). While AN and semi-starvation conditions may share comparable weight loss and similar adaptations in muscle mass morphology and physiology, motor restlessness and the heightened urge to be physically active appear unique to AN (Casper et al., 2020). The urge to be physically active has been observed in 31% to 80% of patients with AN (Hebebrand et al., 2003), and emerging evidence suggests that, following COVID-19, an increase in compulsive exercise behaviors has been observed alongside a general rise in eating disorder cases (Boltri et al., 2024; Devoe et al., 2023).

The concept of the urge to be physically active in AN has been described using various terms in the literature, including compulsive exercise, exercise addiction, excessive physical activity, motor restlessness, and hyperactivity. However, it is often not differentiated between activity and exercise, with exercise being a planned, structured, repetitive, and goal-oriented (e.g., towards fitness) subset of activity. Also, these terms, being used interchangeably, often conflate constructs, such as trait-like compulsive activity or exercise (which reflects persistent, inflexible engagement in physical activity) (Rizk et al., 2020), trait-like exercise addiction (reflecting reward-seeking mechanisms and dependence on exercise for emotional regulation), and state-dependent urges to be active, which may arise acutely in response to internal distress or physiological imbalance.

Here, we build upon the construct of the State Urge to be Physically Active (SUPA), originally introduced and coined by Amin et al. (2023), who first proposed this term to describe a transient, state-dependent condition encompassing motor (akathisia, motor restlessness, fidgeting), emotional (anxiety, inner tension, agitation), and cognitive (thought preoccupation, including intrusive thoughts) aspects. Unlike trait-like constructs such as compulsive exercise or exercise addiction, which are typically assessed as traits, the SUPA represents a momentary urge to be physically active that fluctuates over time and may be influenced by acute physiological, emotional, cognitive, and motivational states (Amin et al., 2023). This conceptualization partially aligns with broader theoretical models describing transient desires and urges for movement, such as the Cravings for Rest and Volitional Energy Expenditure (CRAVE; Stults-Kolehmainen et al., 2021) framework, which conceptualizes motivation for movement and rest as dynamic state-like experiences rather than stable behavioural dispositions. Within this broader framework, CRAVE specifically operationalises the bidirectional motivational continuum regulating both movement and rest across both healthy and clinical populations (Stults-Kolehmainen et al., 2022). In contrast, SUPA represents a more clinically anchored and predominantly dysregulated state characterised by an urgent, often maladaptive drive toward physical activity, as observed in AN, including its potential association with starvation, affect regulation, cognitive preoccupation, and motor restlessness. The SUPA may thus arise as a maladaptive response to energy deficit, stress, or heightened arousal, temporarily alleviating negative affect while reinforcing maladaptive behavioural patterns (Schlegl et al., 2018). Nevertheless, it should be noted that high premorbid physical activity levels have been linked to increased risk of developing hyperactivity both in AN (Davis et al., 1994) and in rodent models of anorexia-based activity (Pjetri et al., 2012).

Emerging evidence suggests an additional biological basis for SUPA, with disruptions in energy homeostasis playing a key role. Alterations in hormone signalling may contribute to motor restlessness and physical activity in AN (Holtkamp et al., 2006). For instance, low leptin levels, reflecting energy deficit, have been associated with increased motor activity (Stengel et al., 2017) and may influence neurobiological pathways involved in affect regulation (e.g., anxiety, rigidity, compulsivity) (Hebebrand et al., 2019). Murine animal models further support this association, showing that extreme dietary restriction can induce paradoxical hyperactivity, which may exacerbate energy imbalance, reduce food intake, and reinforce pathological behaviours characteristic of AN (Adan et al., 2011; Hebebrand et al., 2003). Finally, exogenous application of leptin to food restricted rodents is known to suppress or reduce running wheel activity (Exner et al., 2000; Fernandes et al., 2015).

We explicitly acknowledge that the term SUPA originates from Amin et al. (2023), and we do not claim authorship of the construct. However, to our knowledge, no work to date has systematically operationalized or fully integrated this construct within a broader empirical or theoretical framework, nor has it been clearly differentiated from adjacent motivational states in ED literature. Within this context, the present systematic literature review aims to assess the current state of research on SUPA in all subtypes of AN, including Atypical Anorexia Nervosa (AAN). While BMI has traditionally been considered an indicator of illness severity, emerging clinical and research perspectives suggest that high levels of the urge to be physically active may not be directly related to BMI. Instead, these behaviours may be driven by biological factors and/or psychologically motivated aspects, such as body image distortion and the need for compensatory behaviours (Di Lodovico et al., 2022). Specifically, we seek to examine both objective (motor activity levels) and subjective (motivational, emotional, and cognitive) aspects of the SUPA, and to determine whether physical activity levels vary according to illness severity (e.g., BMI ranges across acute vs. weight restoration phases). By systematically reviewing existing studies, we aim to synthesize current evidence regarding the subjective and objective manifestations of SUPA in AN, examine its proposed biological and psychological correlates, and evaluate its potential clinical implications across illness severity levels. Additionally, we discuss conceptual inconsistencies in the literature and propose directions for future research.

2. Methods

2.1. Search strategy

A systematic search was conducted to identify clinical studies investigating the urge to be physically active in individuals with AN and AAN. The PRISMA guidelines were followed as a methodological framework (Page et al., 2021), and the review was pre-registered on PROSPERO (registration ID: CRD42024527564). Searches were conducted between December 2023 and March 2025 using PubMed, EBSCOhost (PsycINFO, PsycARTICLES, PSYNDEX, MEDLINE, ERIC) and Scopus. Search terms were [("anorexia nervosa" OR "atypical anorexia") AND ("drive for activity" OR "urge to move" OR "compulsive exercise" OR "spontaneous physical activity" OR "hyperactivity" OR "restlessness" OR "akathisia" OR "inability to sit still")]. The exact search string is reported in Supplementary Materials. The research was carried out independently by three researchers (LP, MB, CG) and disagreements were discussed and resolved by consensus.

2.2. Study selection

Although the review includes exploratory and concept-oriented objectives due to the heterogeneity of the literature, it was designed and conducted as a systematic review with predefined eligibility criteria, structured evidence synthesis, and methodological quality assessment.

Given the absence of standardized terminology and operational definitions for state-related activity urges in AN, a broader search strategy was necessary to systematically capture studies investigating overlapping state-dependent manifestations of physical activity urges in this clinical population. In particular, currently available psychometric instruments often insufficiently distinguish between trait-like compulsive exercise and state-dependent urges or motivational drives toward activity. Therefore, studies using measures traditionally associated with compulsive exercise constructs (e.g., Commitment to Exercise Scale;

Davis et al., 1993) were considered eligible only when the study aim, interpretation, or analysed dimensions explicitly addressed acute urges to move, driven exercise, motor restlessness, affect-regulation processes, or other state-related motivational aspects of activity, rather than stable dispositional exercise dependence or trait compulsivity per se. Eligibility criteria were defined as follows: (1) studies investigating the urge to be physically active in terms of "need", "urge", "urgency" and "physiological need" for physical activity and exercise, thus describing a "state" rather than a "trait"; (2) human cohorts; (3) clinical cohorts with a main formal diagnosis of AN or AAN; (4) all age groups; (5) all genders; (6) studies in English and Italian; (7) quantitative studies, such as retrospective and prospective observational studies, case-control studies, cohort studies, prevalence studies, clinical trials, and randomised controlled trials, cross-sectional and longitudinal studies.

The exclusion criteria were as follows: (1) studies investigating physical activity as a behavioural addiction (exercise dependence) and/or dispositional characteristic (trait compulsivity) only, without addressing state-dependent or acute motivational aspects of activity urges, as we were specifically interested in examining transient state-related manifestations rather than stable planned, structured, or repetitive behavioural patterns; (2) studies using the terms "exercise" and "activity" in contexts not relevant to physical movement (e.g., "work activity"); (3) clinical populations with main diagnoses other than AN or AAN; (4) animal studies; (5) qualitative studies; (6) reviews and meta-analyses; (7) ongoing studies, book chapters, and studies from non-scientific journals.

The database search yielded 1165 results (362 from EBSCOhost, 143 from PubMed and 660 from Scopus), of which 816 remained after removal of duplicates. After title and abstract screening, 35 studies were identified as potentially relevant. After full-text screening, 17 studies met the eligibility criteria and were included. Study validity was assessed using the Newcastle-Ottawa Scale (NOS; Wells et al., 2014), suitable for observational studies (cross-sectional, cohort, and case-control studies). Scores were based on three main domains: Selection, Comparability, and Outcome or Exposure (for case-control studies). Studies were then classified as "Very Good", "Good", "Satisfactory", or "Unsatisfactory" by three independent authors (MB, LP, and CG), with no penalties for "Not Applicable" items. One single randomized controlled trial (Harris et al., 2024) was assessed using the Cochrane Risk of Bias tool version 2 (RoB 2.0), which evaluates five domains of potential bias. Two reviewers (MB and CG) independently assessed the study. The study was rated as having "some concerns" overall, due primarily to insufficient information regarding the randomization process (see Supplementary Materials).

Fig. 1 illustrates the entire screening process in a PRISMA flowchart.

3. Results

Findings from the included studies are summarised in Table 1 and presented according to the assessment tools used to evaluate the urge to be physically active in patients with AN. The studies analysed used either objective measures such as the SmartShoe or the SenseWear TM PRO3 armband, or subjective measures such as self-report questionnaires and interviews, or both. The studies included individuals with AN

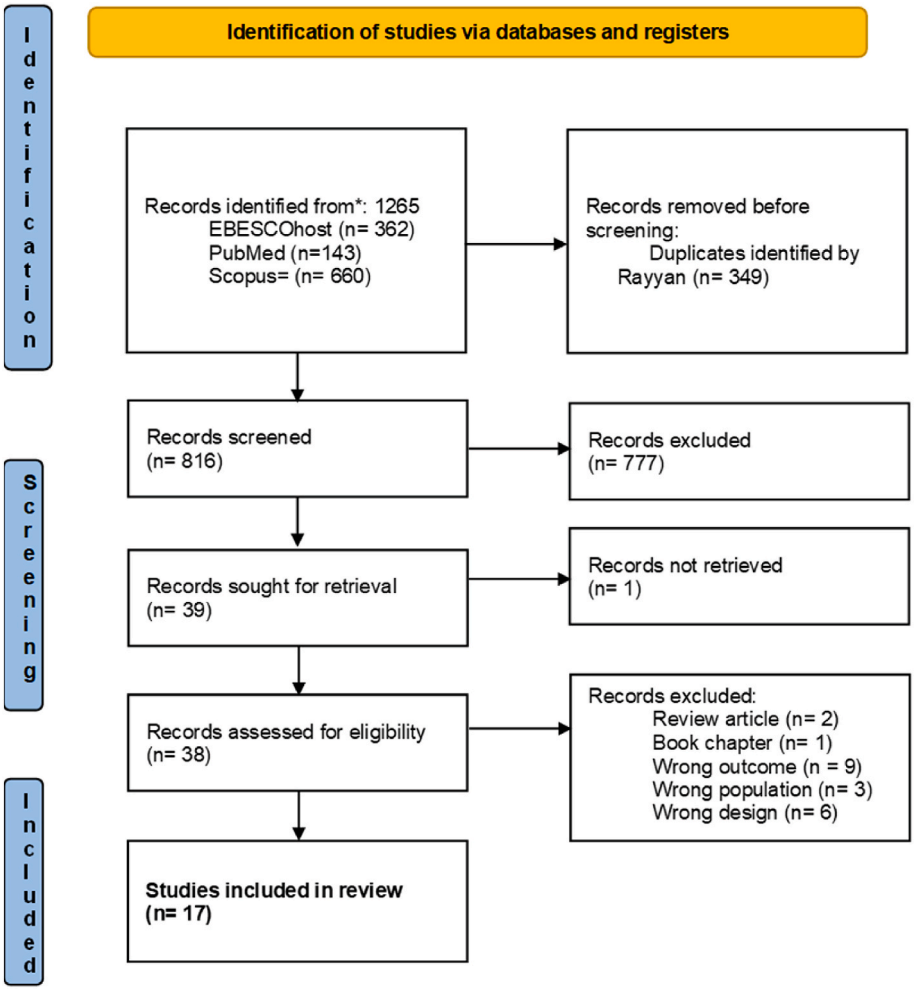


Fig. 1. PRISMA flowchart.

covering the entire spectrum of severity according to the DSM-5-TR (American Psychiatric Association, 2022). The DSM-5-TR describes four markers of severity of AN by BMI status: mild for BMI ≥17 kg/m^2, moderate for BMI between 16 and 16.99, severe for BMI between 15 and 15.99, and extreme when the BMI is < 15 kg/m^2.

3.1. Studies reporting objective measures of the SUPA

Belak and colleagues (Belak et al., 2017) measured sedentary non-exercise physical activity with the SmartShoe device, a shoe detecting changes in posture and movement while standing and sitting. The sample included 11 adult white women with AN, with an average BMI of 17.60 kg/m^2 (SD: ±2.10 kg/m^2) upon assessment, reflecting a mild severity marker. The authors found that BMI was not associated with activity levels. Similarly, another study examined physical activity, measured using the SenseWear armband, in determining BMI restoration during hospitalization of inpatients with AN, and found no direct association between physical activity levels and BMI increase at discharge; conversely, BMI increase was mostly explained by lower admission BMI and longer inpatient stay (Lehmann et al., 2018).

The study by Gianini et al. compared objectively measured physical activity in individuals with AN at low-weight, while weight-restored, and at post-treatment time points (Gianini et al., 2016). Authors used the Intelligent Device for Energy Expenditure and Activity (IDEEA) accelerometer, a novel microcomputer-based portable device. Forty-five women with AN participated in the study, with an average BMI of 16.1 kg/m^2 (±1.0 kg/m^2) at low-weight and 20.2 kg/m^2 (±0.7) during weight restoration. The authors found that higher levels of activity (time on feet measures) during the weight-restored phase predicted a more precipitous rate of decrease in BMI at 12 months following discharge from inpatient treatment ($t = -2.03$, $p = .05$).

Another study examined the effect of ambient temperature on physical activity in women with AN, aged between 12 and 18 years old, in the acute phase of the illness (Carrera et al., 2012). The authors assessed the step count of patients with an accelerometer and compared activity levels in two conditions: the Cold group (activity was measured during autumn and the winter months) and the Warm group (activity measured during spring and summer). Results showed that BMI did not predict physical activity, as measured by step count per day and stratified by intensity (sedentary vs. light vs. moderate). In addition, the study found that the Cold group was significantly more physically active (counts/day) than the Warm group, $p = .003$.

Moreover, two studies investigated the influence of body composition on physical activity in patients with AN (Hofmann et al., 2017; Stengel et al., 2017). Activity was measured using the SenseWear TM PRO3 armband in both studies. Hofmann and colleagues (Hofmann et al., 2017) included 38 women with AN and a mean BMI of 14.8 kg/m^2 (±1.7), while Stengel et al. (2017) enrolled 61 women with AN who had an average BMI of 14.8 (±2.0), indicating an extreme severity of the disorder. Both studies found no associations between physical activity levels and BMI of the participants (Hofmann et al., 2017; Stengel et al., 2017).

The study by Holtkamp and colleagues (Holtkamp et al., 2003) aimed to evaluate whether leptin can influence the level of physical activity in two samples of female adolescents with extreme AN, with an average BMI of 14.46 kg/m^2 (±1.48 for group 1 and ± 1.33 for group 2). Physical activity was assessed for 4 days using an accelerometer, the Actiwatch Sleep Analysis 2001 device (Paquet et al., 2007). In this study, BMI was again not associated with the levels of physical activity displayed by the participants.

Overall, studies utilizing objective measures, such as accelerometers and other activity-tracking devices, consistently found that BMI alone is insufficient to explain the variability in physical activity measures. No association was observed between BMI and activity levels in either patients with mild (Belak et al., 2017), moderate (Carrera et al., 2012), or extreme AN (Hofmann et al., 2017; Holtkamp et al., 2003; Lehmann et al., 2018; Stengel et al., 2017). These findings suggest that physical activity might persist independent of weight status. Gianini et al. (2016) provided additional insights by assessing the urge to be physically active across different timepoints: the study revealed that high levels of physical activity during weight restoration were predictive of more rapid BMI decline post-discharge, emphasizing the enduring psychological drive for activity even when physical recovery has been achieved.

3.2. Studies reporting subjective measures of the SUPA

Vansteelandt and colleagues (Vansteelandt et al., 2007) investigated the within-patient associations between drive for thinness, emotional states, momentary urge to be physically active, and physical activity using Ecological Momentary Assessment. The 32 adolescent and adult women included in the study presented with a mean BMI of 16.71 kg/m^2 (±1.8), representing an overall moderate severity of the disorder. The study found that patients with higher mean levels of their urge to be physically active and higher levels of physical activity were characterized by lower BMI ($par = -0.16$, $p < .05$).

One study looked at interpersonal, affective, and compulsive features of driven exercise in AN (Kolar et al., 2022). The sample consisted of 207 adolescents and adults with AN, with a mean BMI of 15.17 (SD: 1.92); their driven exercise levels were measured using the Commitment to Exercise Scale (CES) (Davis et al., 1993), with a mean score at baseline of 2.93 (SD: 0.68) out of 4. Regarding BMI, no significant correlation was reported to CES levels. On average, individuals reporting higher levels of compulsivity also reported more difficulties in affect regulation; however, trait compulsivity did not significantly moderate the relationship between affect-regulation difficulties and driven exercise measured with the CES.

Another study investigated whether acute activity urges impact discharge weights in AN inpatient (Halbeisen et al., 2024). The authors included a sample of 53 individuals with severe AN, who presented with a mean BMI of 15.67 kg/m^2 (±1.33). Although the authors observed that higher levels of the SUPA, measured via a validated German questionnaire (SUPA-Q) (Amin et al., 2023), were associated with lower early weight gain, they did not observe a significant role of admission BMI ($B = -0.002$, $SE = 0.002$; $Beta = -0.104$, $t = -0.786$, $p = .436$).

The study by Harris et al. looked at the efficacy of the compuLsive Exercise Activity theraPy (LEAP) on compulsive exercise behaviour measured by the Compulsive Exercise Test (CET) (Taranis et al., 2011) and the CES; the predictive validity of the CET's subscales and their ability to predict eating psychopathology were also investigated (Harris et al., 2024). Results showed that the subscales "Avoidance and rule driven behaviour" and "Mood improvement" of the CET predicted exercise behaviour in a group of 78 adult women with AN, with a mean BMI of 16.49 (SD = 1.12). Scores of CET's subscales at baseline were not significant predictors of BMI. Total scores of CET and CES were predictive of eating pathology (semi-partial $R^2 = 0.0982$, $p = .0012$, and semi-partial $R^2 = 0.0689$, $p < .0001$, respectively).

Another study focused on the relationship between the drive for activity (DFA) and the severity of AN (measured by the Eating Disorder Examination- Questionnaire; EDE-Q) (Fairburn and Beglin, 1994), and the impact of negative affect on the association (Sternheim et al., 2015). The sample consisted of 240 women with severe AN, whose mean BMI was 15.8 kg/m^2 (±1.7). The analysis did not reveal any association between DFA and BMI.

Moreover, in a retrospective study on the physical and psychological sequelae following significant weight loss (on average −12.5 kg) in adolescent inpatients with restrictive AN, physical restlessness was found to be positively associated with weight loss both in terms of kg and BMI (Casper et al., 2020). Increases in the urge to be physically active and physical restlessness were strongly associated with self-reported measures of (actual) physical activity and weight loss. The number of women with AN involved in this study was 83; at baseline, they

Table 1
Summary of included studies (n = 17) – Assessment of UPA in AN.

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
Extreme BMI (<15 kg/m^2)													
1.	Casper et al. (2020) Germany	Assess the prevalence of the drive for activity, here operationalized as an increased urge for movement, physical restlessness, and mental restlessness.	ES	N = 83 (women)	16.4 (1,9)	T0: 13.8 (1.6) T1: 16.1 (1.95)	2.16 (1.8)	ANR, diagnosed with ICD-10.	-	BSI CET CES RWLQ	Drive For Activity	n.a.	Increased DFA was positively associated with percentile weight loss ($r = 0.274$, $p < .01$), feeling physically active ($r = 0.337$, $p < .01$), physical restlessness ($r = 0.284$, $p < .05$). Physical agitation correlated with BMI for weight loss ($r = 0.300$) and weight loss in kg ($r = 0.318$, all $p < .01$).
2.	Hofmann et al. (2017) Germany	Investigate the association of PA with hormones (kisspeptin, ghrelin, oxyntomodulin, orexin-A, FGF-21, R-spondin-1) and psychometric parameters and body composition	ES	N = 38 (women)	27.5 (8,9)	14.8 (1.7)	7.9	AN, diagnosed with ICD-10. ANR: 17 ANPB: 11 AAN: 10	SenseWear TM PRO3 armband	-	Physical Activity	n.a.	No significant correlations between PA (total step count) and BMI
3.	Holtkamp et al. (2003) Germany	Define symptoms of AN that are potentially linked to low leptin levels.	ES	Ntot = 88 (women) $N_1 = 61$ $N_2 = 27$	N_1: 17.54 (4,6) yo N_2: 14.54 (1,2) yo	N1: 14.46 (1.4) N2: 14.46 (1.3)	—	AN diagnosed with DSM-IV. ANR:38 ANBP: 18 5 pts without subtype $_2$AN, diagnosed with DSM-IV. ANR: 21 ANPB: 6	SIAB-EX	-	Physical Activity	n.a.	For both group 1 and group 2, the regression model with BMI and leptin explained 37% of the variance in physical activity levels ($R^2 = 0.37$, $p = .003$). Only leptin levels significantly contributed to this variance ($p = .003$), while BMI did not ($p = .205$).
4.	Keyes et al. (2015) UK	Investigate physical activity and drive for exercise in AN in relation to eating	CSS	AN-OP: 35 AN-IP: 17	AN: 29 (−) HC: 29 (−) A: 27 (−)	AN-IP: 14.1 (2.11) AN-OP:		AN, diagnosed with the Structured Clinical	Actiwatch	IPA-Q OEQ EAI REI	Drive to Exercise	n.a.	Patients with AN showed higher self-reported PA compared to HC, while

(*continued on next page*)

Table 1 (*continued*)

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
		disorder pathology and anxiety.				16.04 (1.44)		Interview for DSM (SCID-I/P).					accelerometer-measured PA levels for patients with AN and controls were not significantly different. No difference in levels of drive to exercise was found between AN-IPs and AN-OPs nor depending on the sample's BMI.
5.	Stengel et al. (2017) Germany	Explore the association of leptin and PA in adults with AN using an objective technique to quantify PA.	CSS	N = 61 (women)	25 (-) yo	ANR: 14.6 (2.1) ANBP 15.7 (1.6)	3,6	AN diagnosed with ICD-10. ANR: 49 ANBP: 12	SenseWear TM PRO3 armband	-	Physical activity	n.a.	No significant association between BMI and PA (step count) in both groups
6.	Lehmann et al. (2018) Germany, USA	Investigate the relationship between different PA patterns and BMI increase during inpatient treatment.	CCS	N = 50	25 (21/30) yo	14.4 (2.0)	72 (15/134) months	AN diagnosed with ICD-10.	SenseWear TM PRO3 armband	-	Physical Activity; PA was continuously detected over a 3-day period. A day was included into data analysis if the armband had been worn for at least 20.5 h. They used six different metabolic equivalent (MET) categories to classify different activity intensities of PA	Pre- and post-intervention	Compared to controls, AN patients spent more time in very light (647 vs. 566 min/day, $p = .004$) and light-intensity PA (126 vs. 84 min/day, $p < .001$), and less time in moderate (82 vs. 114 min/day, $p = .022$) and vigorous PA (0 vs. 16 min/day, $p < .001$). PA and BMI increase were not linearly associated; BMI increase was mainly explained by lower admission BMI and longer inpatient stay. In a non-linear model, PA influenced BMI increase (jackknife validation, $r^2 = 0.203$; $p < .001$). No direct link was found between inactivity

(*continued on next page*)

Table 1 (*continued*)

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
													and BMI increase in AN
Severe BMI (15≤BMI≤15,99 kg/m^2)													
7.	Halbeisen et al., 2024 Germany	Investigate whether acute (state- like) activity urges at treatment onset would predict within-person weight gain in patients with AN during the initial 2 weeks of inpatient treatment.	Cohort	N = 53	25.15 (9.74)	15.67 (1.33)		AN diagnosed with ICD-10. ANR: 21 ANBP: 22 AAN: 10	–	SUPAQ CES EDS BIS-15 EDE-Q	Urge to be Physically Active	n.a.	The level of UPA predicted the average daily BMI gain during the 2-week treatment; nevertheless, BMI at admission did not have any effect on this relationship.
8.	Sternheim et al., 2015 Netherlands	Investigate DFA levels in patients with AN and its relation to its severity and the influence of negative affect (anxiety) on DFA	CSS	N = 240 (women)	21,6 (8,9) yo	15.8 (1.7)	5.5 (7.4)	AN, diagnosed with DSM-5. ANR: 145 ANBP: 95	-	DFAQ EDE-Q	Drive for activity	n.a.	No significant differences among subtypes of AN relative to DFA levels. Positive correlation between DFA levels and EDE levels ($r = 0.421$, $p < .001$), and between DFA levels and STAI-T levels ($r = 0.420$, $p < .001$). DFA was predictive of ED ($R^2 = 0.23$)
9.	Kolar et al. (2022) Germany	Test the hypothesis that trait compulsivity predicts a stronger within-person link between affect-regulatory difficulties or interpersonal sensitivity and driven exercise in females with AN	CSS	N = 207	19.23 (5.52) yo	15.17 (1.92)	3.72 (4.48)	AN subtypes and atypical, diagnosed with DSM-IV	-	CES	Driven exercise. Ranges of mean scores: 1-4	They used data from five assessments across inpatient treatment and 6-months follow-up of 207 adult and adolescent patients with AN.	The CES mean score at baseline was 2.93 (SD: 0.68). The between-person correlation of BMI and CES was not significant ($r = 0.01$), but BMI and CES were correlated ($r = 0.53$). Greater affect-regulation difficulties and interpersonal sensitivity were linked to stronger driven exercise. Trait compulsivity amplified the impact of interpersonal

(*continued on next page*)

Table 1 (*continued*)

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
													sensitivity on driven exercise over time but did not moderate the link between affect-regulation difficulties and CES
Moderate BMI (16≤BMI≤16,99 kg/m^2)													
10.	Carrera et al., 2012	Assess the effect of ambient temperature on physical activity in AN patients in the acute phase of the illness, comparing warm to cold months.	CSS	N = 37	15.3 (1.25) (12 to 18 yo only)	16 (1.5)	1.2 (0.79)	AN diagnosed according to the DSM-IV criteria using the Eating Disorder Examination	Actiwatch AW 4	-	Physical Activity. The Actiwatch was worn for three consecutive weekdays, from 9 p.m. on the first day to 9 p.m. on the fourth day, except while swimming and showering.	Patients' enrollment in the study for the Warm group was between April and October, while patient referrals to the eating disorders clinic for the Cold group were between October and April.	Physical activity, as measured by step count per day or stratified by intensity (sedentary vs. light vs. moderate), did not correlate with BMI. A multiple regression analysis showed that BMI did not predict PA. The Cold group was significantly more physically active (counts/day) than the Warm group, p = .003.
11.	Gianini et al. (2016) USA	Compare an objective measurement of PA in individuals with AN at low-weight, weight-restored, and post-treatment time points, and with HC	Cohort	AN: 61 (women)	24,4 (6,5)	AN T1: 16,1 (1) AN T2: 20,2 (0,7) AN T3: 19,5 (2)	8.3 (6.6)	AN, based on DSM-5 criteria at the time of hospital admission	IDEEA accelerometer	-	Physical Activity and Fidgeting	Low-weight, weight restoration, one month post-discharge.	AN patients showed significantly higher activity levels at weight restoration (Time 2) and one month post-discharge (Time 3) compared to low-weight (Time 1), with Time 3 activity exceeding Time 2 activity. Fidgeting did not differ significantly across time points.
12.	Vansteelandt et al. (2007) Belgium	Using EMA, within-patient links between drive for thinness, emotions, UPA, and PA were studied in ED inpatients	Cohort	N tot = 32 N AN-R = 14 N AN-BP = 5	M age (SD) tot: 21.6 (6.7) yo	AN: 16.71 (1.80)	—	AN and BN according to the Diagnostic and Statistical Manual of Mental Disorders 4th	-	EDI PANAS BDI SCL-90	Urge to be Physically Active	n.a.	Patients with higher mean levels of UPA were characterized by low BMI (par = −0.16, p < .05), chronic negative affect (par = 0.58, p < .01), and a strong drive for

(*continued on next page*)

Table 1 (*continued*)

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
								edition (DSM-IV)					thinness (par = 0.18, p < .001).Within patient associations between DT and UPA were moderated by BMI and chronically negative affect. Positive emotional states were significantly associated with PA in patients.
13.	Bezzina et al., 2019 Australia, USA, UK	Examined self-reported vs. objective PA accuracy in AN patients and its links to compulsive exercise, motivation, and distress	Observational CSS	N = 34 (32 women, 2 men)	26.3 (6.4) (Female: 32, Male: 2)	16.4 (SD: 1.2)	-	AN diagnosed with DSM-5	ActiGraph	EPS-Q CET	Physical exercise	At baseline, participants completed questionnaires and were asked to wear the accelerometer on an elastic belt around their waist for 4 days (but not when in bed, while showering or swimming).	Patients significantly under-reported total PA compared to accelerometer data (p < .001), mainly due to under-reporting light-intensity PA. Moderate and vigorous PA were reported accurately. Higher compulsive exercise scores correlated with more accurate total PA reporting (r = 0.36, p = .04).
14.	Harris et al., 2024 Australia, USA, UK	Investigate the effect of Compulsive Exercise Activity Therapy (LEAP) on compulsive exercise behaviour using subscales of the CET. Predictive validity of the CET's subscales and its ability to predict eating psychopathology are investigated.	RCT	N = 78 (74 women, 4 men)	27.12 (SD = 9.17)	16.49 (SD = 1.12)	AN onset (SD): 18.45 (6.4) years old	AN diagnosed with DSM-5.	-	CES CET	Compulsive exercise	At baseline and post-intervention	'Avoidance and rule-driven behavior' (EDE-Q item 18) and 'Mood improvement' (CET) predicted exercise frequency. Baseline CET subscales did not predict BMI. Total CET and CES scores predicted eating pathology (semi-partial $R^2 = 0.0982$, p = .0012; $R^2 = 0.0689$, p < .0001), with CET being the strongest predictor

(*continued on next page*)

Table 1 (*continued*)

	Authors, publication year and countries	Objective	Study design	Sample size	Mean (SD) age, years	BMI M (SD)	Illness duration (years (SD))	Diagnosis	Assessment instrument		Term used by authors, definition and cut-offs	Time of assessment	Main results
									Objectively	Subjectively			
15.	Young et al., 2017Australia, UK, USA	Assess the concurrent validity of EDE/EDE-Q exercise items with the CET and other measures in AN patients, and validated the CET in an adult clinical sample	CSS	N = 78	27.12 (9.17)	16.49 (1.12)	5.53 (7.80)	AN diagnosed with DSM-5.	-	CES CET	Compulsive Exercise	n.a.	Exercise frequency (EDE measures) was significantly related to compulsive exercise (CET-Total) and higher ED psychopathology. CES predicted less variance in ED psychopathology than CET
Mild BMI (≥17 kg/m^2)													
16.	Paslakis et al. (2017) Germany	Test a VR paradigm to induce an acute urge for physical activity under controlled therapeutic conditions	PS	N = 30 (women)	_	AN: 17.08 (1.74) BN: 22.36 (2.02)		AN: 20 BN: 10 Diagnosed with DSM-5.	-	SUPAQ CET	State Urge to be Physically Active	n.a.	Changes not associated with any of the variables considered (BMI, baseline plasma leptin, D-cortisol or D-cortisone).
17.	Belak et al., 2017 USA	Objectively assessed seated non-exercise activity in AN patients vs. controls, and examined links with ED pathology, anxiety, and depression	CSS	Ntot = 21 N AN: 11 (women)	AN: 24,50 (6)	17.60 (2.10)	9.80 (5.60)	AN, diagnosed with DSM-5. ANR: 9 ANBP: 2	SmartShoe	-	Physical Activity	n.a.	No significant correlation between patients' rate of weight gain and activity level (r = −. 11, p = .76)

Abbreviations: AAN: Atypical Anorexia Nervosa; AN: Anorexia Nervosa; ANBP: Anorexia Nervosa Binge/Purging type; ANR: Anorexia Nervosa Restricting type; BDI: Beck Depression Inventory; BMI: Body Mass Index; BN: Bulimia Nervosa; BSI: Brief Symptoms Inventory; CCS: Case-Control Study; CES: Commitment to Exercise Scale; CET: Compulsive Exercise Test; CS: Correlational Study; CSS: Cross-Sectional Study; DASS: Depression Anxiety Stress Scale 21-Version; DFA: Drive for Activity; DFAQ: Drive for Activity Questionnaire; EAI: Exercise Addiction Inventory; EDE: Eating Disorder Examination; EDE-Q: Eating Disorder Examination Questionnaire; EDI-2: Eating Disorder Inventory 2 edition; EDS-21: Eating Disorder Symptomatology – 21; EE: Excessive Exercise; ED: Eating Disorder; EMA: Ecological Momentary Assessment; EPS-Q: Exercise Participation Screening Questionnaire; ES: Exploratory Study; FGF-21: Fibroblast Growth Factor 21; GAD: Generalized Anxiety Disorder; GAD-7: Generalized Anxiety Disorder-7; HC: Healthy Controls; IDEEA: Intelligent Device for Energy Expenditure and Activity; IN: Inner Restlessness; IPA-Q: International Physical Activity Questionnaire; MO: Motor Restlessness; N: Sample size; n.a.: not available; OEQ: Obligatory Exercise Questionnaire; PA: Physical Activity; PANAS: Positive and Negative Affect Schedule; PHQ-9: Patient Health Questionnaire-9; PS: Pilot Study; PSQ-20: Perceived Stress Questionnaire-20; pt: patient; REI: Reasons for Exercise Inventory; RWLQ: Reactions to Weight Loss Questionnaire; SCL-90: Symptom Checklist-90; SCID-I/P: Structured Clinical Interview for DSM, Research Version/Patient Edition; SIAB-EX: Structured Interview for Anorexic and Bulimic Disorders for Expert; SD: Standard Deviation; smQ: a 10-item self-report questionnaire; STAI-T: State-Trait Anxiety Inventory trait subscale; SUPA-Q: Subjective Urge to be Physically Active-Questionnaire; VAS: Visual Analogue Scale; VR: Virtual Reality Visor.

presented with extreme AN and an average BMI of 13.8 kg/m^2 (±1.6), whereas at weight restoration the illness turned to moderate, with a mean BMI of 16.1 kg/m^2 (±1.95).

Finally, a study aimed at evaluating the efficiency of a novel virtual reality (VR) exposure paradigm, involving simulated jogging, to reduce the urge to be physically active in patients with eating disorders (Paslakis et al., 2017). To do so, the authors measured both subjective urge and potential hormonal changes. The acute urge to be physically active was measured using the State Urge to be Physically Active Questionnaire (SUPA-Q) (Amin et al., 2023) before and after the VR exposure. The study included 20 women with AN who reported a mean BMI of 17.1 kg/m^2 (±1.74), thus of mild severity. The authors found that the self-reported levels of the state urge to be physically active were not associated with BMI.

Overall, studies using subjective assessments showed mixed results, either by revealing no association (i.e., aligning with the aforementioned studies applying objective assessments) or a weak association between (low) BMI and (high) urge to be physically active, underscoring the psychological persistence of the urge to engage in activity across a BMI range (Sternheim et al., 2015; Vansteelandt et al., 2007). Some evidence suggests that compulsive exercise might be used as a regulatory strategy for emotional distress, and one study showed how trait compulsivity, however, was not a moderator between affect-regulation and driven exercise (Kolar et al., 2022). At the same time, the studies by Casper et al. (2020) and Halbeisen et al. (2024) both suggest that self-reported state urges may impact clinical outcomes, being linked to both weight loss and reduced early weight gain during treatment.

3.3. Studies reporting double measures of the SUPA

A study investigated the relationship between the urge to be physically active and physical activity in AN, applying both an objective measurement (actigraphy) and self-report measurements for physical activity (Keyes et al., 2015). The study included 17 inpatients (mean BMI: 14.1 ± 2.11 kg/m^2) and 35 outpatients (mean BMI: 16.04 ± 1.44 kg/m^2) with AN, representing extreme and moderate AN, respectively. This study found that patients with AN self-reported higher physical activity compared to healthy controls, while accelerometer-measured physical activity levels for patients with AN and controls were not significantly different. In addition, the authors reported that the levels of the drive to exercise did not depend on the sample's BMI.

Another study aimed to examine the accuracy of self-reported physical activity (measured by the Exercise Participation Screening Questionnaire, EPS-Q and CET) compared to an objective measure by means of an accelerometer in adults with AN and a mean BMI of 16.4 (SD: 1.2), and to investigate whether levels of accuracy/inaccuracy were associated with compulsive exercise, motivation to change, and psychological distress (Bezzina et al., 2019). The total discrepancy between daily physical activity recorded on accelerometers and self-report EPS-Q was significant ($p < .001$), indicating a general subjective under-assessment (and/or under-reporting) of overall physical activity. On the self-report measure, patients accurately reported their time spent in moderate and vigorous intensity physical activity; however, they significantly under-reported their light physical activity compared to the accelerometer data. Accurate reporting of total physical activity was positively associated with higher levels of compulsive exercise, with Spearman's correlations between total discrepancy and compulsive exercise significant at $r = 0.36$, $p = .04$.

Overall, two studies employed both objective and subjective measures, providing contrasting evidence regarding the congruence between subjective and objective measurements of physical activity among individuals with AN (Bezzina et al., 2019; Keyes et al., 2015). Moreover, one study confirmed the persistence of the urge to be physically active regardless of BMI (Keyes et al., 2015).

4. Discussion

4.1. The state urge to be physically active (SUPA) across illness severity levels in AN

Early clinical descriptions from the 1700s presented patients with AN as restless and physically active despite extreme underweight (Gull, 1868; Laségue, 1873; Miller and Pumariega, 2001). Modern research confirms this phenomenon as a pervasive feature across illness stages (Gianini et al., 2016; Harris et al., 2024; Paslakis et al., 2017; Sternheim et al., 2015). In this systematic review we investigated the State Urge to be Physically Active (SUPA), defined as the transient, state-dependent urge to engage in activity, encompassing motor (e.g., restlessness, pacing), emotional (e.g., inner tension, anxiety), and cognitive (e.g., intrusive thoughts regarding activity) components, which are dependent upon and may fluctuate along with physiological or psychological states.

Across the reviewed literature, SUPA emerged as a feature regardless of the acuity of the disorder or BMI level. Studies employing objective activity measures such as accelerometers and wearable activity trackers revealed no significant relationship between BMI and physical activity levels, even during phases of weight restoration (Belak et al., 2017; Gianini et al., 2016; Hofmann et al., 2017; Holtkamp et al., 2003; Stengel et al., 2017). Likewise, self-assessments indicated that the urge to be physically active often persists independently of changes in weight, with individuals frequently reporting a psychological drive for activity that remains unchanged despite improvements in nutritional status or BMI (Casper et al., 2020; Halbeisen et al., 2024; Sternheim et al., 2015; Vansteelandt et al., 2007). Such findings suggest that SUPA may be more closely linked to affective and cognitive processes, such as distress intolerance, anxiety (dys-)regulation, or cognitive rigidity rather than to metabolic status alone (Harris et al., 2024; Paslakis et al., 2017; Sternheim et al., 2015) or dispositional compulsivity (Kolar et al., 2022). Evidence also points to the clinical relevance of this phenomenon. For instance, Gianini et al. (2016) demonstrated that high levels of physical activity during weight restoration were predictive of subsequent BMI decrease, underlining the potential of SUPA to undermine recovery. Additional findings by Carrera et al. (2012) suggest that environmental factors, such as seasonality, may influence activity patterns, with increased physical activity levels noted in colder months. Together, these findings suggest that SUPA may play a crucial role in hindering weight gain, should be proactively considered in clinical settings and evaluated as a key factor contributing to low weight maintenance in AN, alongside body-image related concerns and the fear of gaining weight (Maurel et al., 2024).

4.2. Neurometabolic mechanisms associated with SUPA in AN

Based on the lack of strong evidence of a relationship between BMI and SUPA, we propose to move beyond BMI in future studies. However, before doing so, we need to consider if this lack is not due to insufficient designs to capture such a relationship. Our results show that SUPA is not related to BMI cross-sectionally. In longitudinal designs, substantial and prolonged weight gain may be required to reduce SUPA; none of the longitudinal studies have addressed the possibility of a threshold, according to which a sufficiently high BMI (e.g. achievement of premorbid BMI) must be achieved to reduce SUPA. It may well be that the duration of previous longitudinal studies may have been too short and that weight gain was too low. Because starvation related effects are known to persist for a prolonged time despite weight gain (Hebebrand et al., 2022; Keys et al., 1950), it may be a very complex endeavour to accomplish both a long duration and high weight gain within a prospective longitudinal study.

In the following, we discuss both biological and psychological explanations for the apparent lack of relationship between BMI and SUPA. Before doing so, we also need to consider the possibility of SUPA being a heterogeneous phenotype. For example, some patients with a higher

premorbid BMI may intentionally lose weight by increasing their activity levels; SUPA in these patients may mechanistically differ from SUPA in a patient who developed AN after unintentional weight loss. Starting off with biologically-oriented explanations, we need to realize that the staging of AN based on BMI has no established validity in terms of any clinically relevant variable (Engelhardt et al., 2021). The fact that premorbid BMI is highly correlated with weight loss in kg (Hebebrand et al., 2024; Matthews et al., 2024), indicates that premorbid lean patients may lose very little weight, whereas premorbid overweight patients may lose a significant number of kg. Nevertheless, the admission BMI may then be higher in those patients who had premorbid overweight. In light of the strong evidence linking hypoleptinemia to the development of hyperactivity in rodent models, it would represent a major advance if future studies systematically assessed leptin secretion in patients with SUPA. However, current evidence warrants strong considerations as to the appropriate study designs. The relationship between circulating leptin levels may be non-linear; Holtkamp et al. (2006) described an inverted U-shaped relationship. We need to also consider time lags; thus, an acute increment in circulating leptin may need to persist for a while for induction of post-receptor changes, which importantly include structural changes in thalamus, hippocampus and amygdala (Bahnsen et al., 2024; Wronski et al., 2023, 2024, 2025). A placebo-controlled clinical trial may more directly determine whether and to what extent human recombinant leptin (metreleptin) has an impact on activity levels (Antel et al., 2022; Milos et al., 2020). Obviously, a search for other biomarkers is warranted too.

4.3. The clinical significance of SUPA in early illness and treatment response

Across the reviewed studies, SUPA emerged as a recurrent and transdiagnostic feature of AN. However, no differences were reported based on AN subtypes (restricting vs. binge-purging), and none of the included studies focused specifically on atypical AN. Rather than reflecting a distinct clinical phenotype, high SUPA levels appear to be pathognomonic of the disorder, regardless of BMI levels. Clinically, SUPA remains under-recognized and unaddressed, despite evidence linking it to reduced early weight gain (Halbeisen et al., 2024) and increased weight loss in retrospective accounts (Casper et al., 2020); these findings underscore its relevance as a potential prognostic marker during early treatment phases, in need of further research.

It appears important to assess the different facets of SUPA, e.g., cognitive preoccupations or emotional dysregulation, which may differ between patients. SUPA may function as a maladaptive emotion regulation strategy, as suggested by Harris et al. (2024), especially in individuals with heightened interpersonal sensitivity (Kolar et al., 2022), and may intensify when other compensatory behaviours (e.g., self-induced vomiting or laxatives) are inaccessible during treatment. This highlights the importance of monitoring SUPA as a dynamic and clinically highly relevant symptom.

4.4. How to assess SUPA: implications for research and clinical practice

The adequate assessment of SUPA is associated with important methodological challenges. Existing psychometric tools commonly used to assess problematic physical activity in eating disorders, such as the CET and CES measures, were primarily developed to capture compulsive, dependence-like, or trait-related dimensions of exercise behaviour. As such, they may insufficiently distinguish stable dispositional compulsivity from acute, state-dependent urges to be physically active, including motivational, affective, cognitive, and motor-restlessness components. This represents an important limitation in the current literature and was one of the reasons motivating the conceptual development of SUPA as a distinct, state-oriented construct. Notably, in their literature synthesis, Harris et al. (2020) found that mood improvement, rather than weight control and exercise rigidity, was the strongest predictor of exercise frequency, thus emphasizing the state affective dimension of SUPA. Subjective assessments, such as self-report questionnaires (e.g., the SUPA-Q), may therefore offer more nuanced insights into internal urges, alongside objective tools able to quantify behavioural manifestations. This double approach appears to be essential to fully capture the complexity of the SUPA manifestation in AN. Additionally, biological factors such as leptin and other appetite-regulating hormones may contribute to the emergence and persistence of SUPA, although their precise involvement remains unclear and warrants further investigation. Combining psychological, objective-behavioural, and biological data may help to better reveal underlying pathomechanisms and inform targeted interventions. Moreover, the integration of innovative technologies, such as virtual reality, into specialised treatment protocols may offer new opportunities for addressing SUPA in patients with AN (Boltri et al., 2025; Halbeisen et al., 2025; Paslakis et al., 2017). The clinical application of such tools should be considered as part of an integrated therapeutic approach, providing patients with alternatives to manage the pathological urge to be physically active.

4.5. Limitations and future directions

This systematic review explores the characteristics and clinical associations of SUPA in AN, but several limitations related to both the review methodology and the available literature need to be considered. Due to the exploratory nature of the field, characterised by heterogeneous terminology, varying conceptualisations and diverse assessment methods, the present review partially overlaps with scoping reviews, particularly regarding conceptual clarification and identification of research gaps. Nevertheless, the present study was designed and conducted as a systematic review, following PRISMA guidelines and employing predefined eligibility criteria, systematic literature searches, independent screening procedures, formal methodological quality assessment, and a structured synthesis of empirical findings. One key issue concerns the classification of AN severity across included studies, typically based on BMI, with high variability and large standard deviations. Moreover, varying terminologies describing intentional weight loss/starvation syndrome vs. broader weight loss conditions hinder comparability. For instance, some studies (Holtkamp et al., 2003; Sternheim et al., 2015) used “food restriction” to describe intentional weight loss in AN, while others (i.e., Casper et al., 2020) employed “weight loss” more broadly, including non-dietary causes such as medical conditions. Thus, a unified framework for defining and categorizing weight-related phenomena in AN is needed. Similarly, future studies should adopt standardized operational definitions to clarify the distinction between SUPA-associated constructs, as well as their impact on metabolic and psychological outcomes. Methodologically, most studies rely on small, predominantly female adolescent samples, which restricts the generalizability of findings to males and adults. The scarcity of standardized tools that specifically assess SUPA also challenges the validity of current findings. To our knowledge, the SUPA-Q represents a pioneering tool to measure the urge to move, but its validation remains limited to contexts like Germany (Amin et al., 2023). Future research should prioritize developing validated, universally applicable instruments. Additionally, perceptual distortions may complicate the assessment of SUPA, as studies combining subjective and objective data (Bezzina et al., 2019; Keyes et al., 2015) show that patients tend to underestimate light activity, particularly when compulsive tendencies are high. This highlights the need for multi-modal assessment approaches integrating self-report and objective data. A coordinated effort toward consistent research protocols and a shared lexicon is essential for advancing SUPA understanding and guiding more effective interventions.

5. Conclusion

Literature suggests that the SUPA may be a core feature of AN, persisting across all BMI severity levels and weight restoration status. Routine clinical practice should systematically assess and monitor SUPA, while research should clarify its role in hindering weight gain or sustaining low weight, as well as evaluate targeted treatments, such as hormonal therapies and VR-based exposure. Validated tools and standardized definitions are crucial to enhance interventions.

Funding

This work was supported by the Italian Ministry of Health -Ricerca Corrente.

CRediT authorship contribution statement

Margherita Boltri: Conceptualization, Formal analysis, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Carolina Gabutti:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Lara Pignattai:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Federico Brusa:** Supervision, Writing – review & editing. **Emanuela Apicella:** Supervision, Writing – review & editing. **Gianluca Castelnuovo:** Supervision, Writing – review & editing. **Walter Sapuppo:** Supervision, Writing – review & editing. **Leonardo Mendolicchio:** Funding acquisition, Supervision, Writing – review & editing. **Mouna Hanachi:** Supervision, Writing – review & editing. **Johannes Hebebrand:** Conceptualization, Supervision, Writing – review & editing. **Georgios Paslakis:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no competing interests.

Acknowledgements

Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2026.06.022.

References

Adan, R.A.H., Hillebrand, J.J.G., Danner, U.N., Cano, S.C., Kas, M.J.H., Verhagen, L.A. W., 2011. Neurobiology driving hyperactivity in activity-based anorexia. Current Topics in Behavioral Neurosciences 6 (1), 229–250. https://doi.org/10.1007/7854_2010_77.

American Psychiatric Association, 2022. Diagnostic and statistical manual of mental disorders. Diagnostic and Statistical Manual of Mental Disorders. https://doi.org/10.1176/APPI.BOOKS.9780890425787.

Amin, L., Halbeisen, G., Braks, K., Huber, T.J., Paslakis, G., 2023. The State Urge to be Physically Active-Questionnaire (SUPA-Q): Development and validation of a state measure of activity urges in patients with eating disorders. Brain and Behavior 13 (10), e3220. https://doi.org/10.1002/BRB3.3220.

Antel, J., Tan, S., Grabler, M., Ludwig, C., Lohkemper, D., Brandenburg, T., Barth, N., Hinney, A., Libuda, L., Remy, M., Milos, G., Hebebrand, J., 2022. Rapid amelioration of anorexia nervosa in a male adolescent during metreleptin treatment including recovery from hypogonadotropic hypogonadism. Eur. Child Adolesc. Psychiatr. 31 (10), 1573–1579. https://doi.org/10.1007/S00787-021-01778-7.

Aspen, Jean, 1993. Arctic daughter: a wilderness journey 205.

Bahnsen, K., Wronski, M.L., Keeler, J.L., King, J.A., Preusker, Q., Kolb, T., Weidner, K., Roessner, V., Bernardoni, F., Ehrlich, S., 2024. Differential longitudinal changes of hippocampal subfields in patients with anorexia nervosa. Psychiatr. Clin. Neurosci. 78 (3), 186–196. https://doi.org/10.1111/PCN.13626.

Belak, L., Gianini, L., Klein, D.A., Sazonov, E., Keegan, K., Neustadt, E., Walsh, B.T., Attia, E., 2017. Measurement of fidgeting in patients with anorexia nervosa using a novel shoe-based monitor. Eat. Behav. 24, 45–48. https://dx.doi.org/10.1016/j.eatbeh.2016.11.005.

Bezzina, L., Touyz, S., Young, S., Foroughi, N., Clemes, S., Meyer, C., Arcelus, J., Madden, S., Attia, E., Pike, K.M., Hay, P., 2019. Accuracy of self-reported physical activity in patients with anorexia nervosa: links with clinical features. J. Eat. Disord. 7 (1), 28. https://doi.org/10.1186/S40337-019-0258-Y.

Boltri, M., Brizzi, G., Brusa, F., Gabutti, C., Cera, G., Scalia, A., Manzo, F., Apicella, E., Castelnuovo, G., Riva, G., Mendolicchio, L., 2025. Virtual reality-based running exposure to target the acute urge to be physically active in Anorexia Nervosa: a case series. Neuropsychobiology 84 (4), 184–196. https://doi.org/10.1159/000547031.

Boltri, M., Brusa, F., Apicella, E., Mendolicchio, L., 2024. Short- and long-term effects of Covid-19 pandemic on health care system for individuals with eating disorders. Front. Psychiatr. 15. https://doi.org/10.3389/FPSYT.2024.1360529.

Carrera, O., Adan, R.A.H., Gutierrez, E., Danner, U.N., Hoek, H.W., van Elburg, A.A., Kas, M.J.H., 2012. Hyperactivity in anorexia nervosa: warming up not just burning-off calories. PLoS One 7 (7). https://doi.org/10.1371/JOURNAL.PONE.0041851.

Casper, R.C., 2006. The "drive for activity" and 'restlessness' in anorexia nervosa: potential pathways. J. Affect. Disord. 92 (1), 99–107. https://doi.org/10.1016/J.JAD.2005.12.039.

Casper, R.C., 2016. Restless activation and drive for activity in anorexia nervosa may reflect a disorder of energy homeostasis. Int. J. Eat. Disord. 49 (8), 750–752. https://doi.org/10.1002/EAT.22575.

Casper, R.C., Voderholzer, U., Naab, S., Schlegl, S., 2020. Increased urge for movement, physical and mental restlessness, fundamental symptoms of restricting anorexia nervosa? Brain and Behavior 10 (3). https://doi.org/10.1002/BRB3.1556.

Davis, C., Brewer, H., Ratusny, D., 1993. Commitment to exercise Scale. PsycTESTS Dataset. https://doi.org/10.1037/T53199-000.

Davis, C., Kennedy, S.H., Ravelski, E., Dionne, M., 1994. The role of physical activity in the development and maintenance of eating disorders. Psychol. Med. 24 (4), 957–967. https://doi.org/10.1017/S0033291700029044.

Devoe, D.J., Han, A., Anderson, A., Katzman, D.K., Patten, S.B., Soumbasis, A., Flanagan, J., Paslakis, G., Vyver, E., Marcoux, G., Dimitropoulos, G., 2023. The impact of the COVID-19 pandemic on eating disorders: a systematic review. Int. J. Eat. Disord. 56 (1), 5–25. https://doi.org/10.1002/EAT.23704.

Di Lodovico, L., Hanachi, M., Duriez, P., Gorwood, P., 2022. The fitter I Am, the larger I Feel—The vicious circle of physical exercise in Anorexia Nervosa. Nutrients 14 (21). https://doi.org/10.3390/NU14214507.

Engelhardt, C., Föcker, M., Bühren, K., Dahmen, B., Becker, K., Weber, L., Correll, C.U., Egberts, K.M., Ehrlich, S., Roessner, V., Fleischhaker, C., von Gontard, A., Hahn, F., Jenetzky, E., Kaess, M., Legenbauer, T., Renner, T.J., Schulze, U.M.E., Sinzig, J., et al., 2021. Age dependency of body mass index distribution in childhood and adolescent inpatients with anorexia nervosa with a focus on DSM-5 and ICD-11 weight criteria and severity specifiers. Eur. Child Adolesc. Psychiatr. 30 (7), 1081–1094. https://doi.org/10.1007/S00787-020-01595-4.

Exner, C., Hebebrand, J., Remschmidt, H., Wewetzer, C., Ziegler, A., Herpertz, S., Schweiger, U., Blum, W.F., Preibisch, G., Heldmaier, G., Klingenspor, M., 2000. Leptin suppresses semi-starvation induced hyperactivity in rats: implications for anorexia nervosa. Mol. Psychiatr. 5 (5), 476–481. https://doi.org/10.1038/SJ.MP.4000771.

Fairburn, C.G., Beglin, S.J., 1994. Assessment of eating disorders: interview or self-report questionnaire? Int. J. Eat. Disord. https://onlinelibrary.wiley.com/doi/epdf/10.1002/1098-108X%28199412%2916%3A4%3C363%3A%3AAID-EAT2260160405%3E3.0.CO%3B2-%23.

Fernandes, M.F.A., Matthys, D., Hryhorczuk, C., Sharma, S., Mogra, S., Alquier, T., Fulton, S., 2015. Leptin suppresses the rewarding effects of running via STAT3 signaling in dopamine neurons. Cell Metab. 22 (4), 741–749. https://doi.org/10.1016/j.cmet.2015.08.003.

Gianini, L.M., Klein, D.A., Call, C., Walsh, B.T., Wang, Y., Wu, P., Attia, E., 2016. Physical activity and post-treatment weight trajectory in anorexia nervosa. Int. J. Eat. Disord. 49 (5), 482–489. https://doi.org/10.1002/eat.22495.

Gull, W.W., 1868. Anorexia nervosa (apepsia hysterica, anorexia hysterica). Obes. Res. 5 (5), 498–502. https://doi.org/10.1002/J.1550-8528.1997.TB00677.X.

Halbeisen, G., Amin, L., Braks, K., Huber, T.J., Paslakis, G., 2024. Acute activity urges predict lower early weight gain during inpatient treatment for Anorexia Nervosa. Int. J. Eat. Disord. 57 (12). https://doi.org/10.1002/EAT.24305.

Halbeisen, G., Timmesfeld, N., Paslakis, G., 2025. Reducing the urge to be physically active in patients with anorexia nervosa through virtual reality: protocol for a randomised-controlled feasibility trial. BMJ Open 15, e097886. https://doi.org/10.1136/bmjopen-2024-097886.

Harris, A., Hay, P., Touyz, S., 2020. Psychometric properties of instruments assessing exercise in patients with eating disorders: a systematic review. J. Eat. Disord. 8 (1), 1–14. https://doi.org/10.1186/S40337-020-00315-2/TABLES/2.

Harris, A., Mannan, H., Hay, P., Aouad, P., Arcelus, J., Attia, E., Crosby, R., Madden, S., Meyer, C., Touyz, S., 2024. Assessment and treatment of compulsive exercise in anorexia nervosa – a combined investigation of compulsive Exercise Activity Therapy (LEAP) and compulsive Exercise Test subscales. Eat. Behav. 52. https://doi.org/10.1016/j.eatbeh.2023.101825.

Hebebrand, J., Exner, C., Hebebrand, K., Holtkamp, C., Casper, R.C., Remschmidt, H., Herpertz-Dahlmann, B., Klingenspor, M., 2003. Hyperactivity in patients with anorexia nervosa and in semistarved rats: evidence for a pivotal role of hypoleptinemia. Physiol. Behav. 79 (1), 25–37. https://doi.org/10.1016/S0031-9384(03)00102-1.

Hebebrand, J., Hildebrandt, T., Schlögl, H., Seitz, J., Denecke, S., Vieira, D., Gradl-Dietsch, G., Peters, T., Antel, J., Lau, D., Fulton, S., 2022. The role of hypoleptinemia in the psychological and behavioral adaptation to starvation: implications for anorexia nervosa. Neurosci. Biobehav. Rev. 141. https://doi.org/10.1016/j.neubiorev.2022.104807.

Hebebrand, J., Milos, G., Wabitsch, M., Teufel, M., Führer, D., Bühlmeier, J., Libuda, L., Ludwig, C., Antel, J., 2019. Clinical trials required to assess potential benefits and side effects of treatment of patients with Anorexia Nervosa with recombinant Human Leptin. Front. Psychol. 10 (MAY). https://doi.org/10.3389/FPSYG.2019.00769.

Hebebrand, J., Seitz, J., Föcker, M., Viersen, H. P. van, Huss, M., Bühren, K., Dahmen, B., Becker, K., Weber, L., Correll, C.U., Jaite, C., Egberts, K., Romanos, M., Ehrlich, S., Seidel, M., Roessner, V., Fleischhaker, C., Möhler, E., Hahn, F., et al., 2024. Premorbid body weight predicts weight loss in both anorexia nervosa and atypical anorexia nervosa: further support for a single underlying disorder. Int. J. Eat. Disord. 57 (4), 967–982. https://doi.org/10.1002/EAT.24189.

Hofmann, T., Elbelt, U., Haas, V., Ahnis, A., Klapp, B.F., Rose, M., Stengel, A., 2017. Plasma kisspeptin and ghrelin levels are independently correlated with physical activity in patients with anorexia nervosa. Appetite 108, 141–150. https://doi.org/10.1016/J.APPET.2016.09.032.

Holtkamp, K., Herpertz-Dahlmann, B., Hebebrand, K., Mika, C., Kratzsch, J., Hebebrand, J., 2006. Physical activity and restlessness correlate with leptin levels in patients with adolescent anorexia nervosa. Biol. Psychiatry 60 (3), 311–313. https://doi.org/10.1016/J.BIOPSYCH.2005.11.001.

Holtkamp, K., Herpertz-Dahlmann, B., Mika, C., Heer, M., Heussen, N., Fichter, M., Herpertz, S., Senf, W., Blum, W.F., Schweiger, U., Warnke, A., Ballauff, A., Remschmidt, H., Hebebrand, J., 2003. Elevated physical activity and low leptin levels co-occur in patients with anorexia nervosa. The Journal of Clinical Endocrinology and Metabolism 88 (11), 5169–5174. https://doi.org/10.1210/JC.2003-030569.

Keyes, A., Woerwag-Mehta, S., Bartholdy, S., Koskina, A., Middleton, B., Connan, F., Webster, P., Schmidt, U., Campbell, I.C., 2015. Physical activity and the drive to exercise in anorexia nervosa. Int. J. Eat. Disord. 48 (1), 46–54. https://doi.org/10.1002/eat.22354.

Keys, A., Brozek, J., Henschel, A., Mickelsen, O., Taylor Longstreet, H., 1950. The biology of human starvation. The Biology of Human Starvation. https://doi.org/10.5749/J.CTV9B2TQV.

Keys, A., Brožek, J., Henschel, A., Mickelsen, O., Longstreet Taylor, H., 1952. The biology of human starvation. Nature 1952 170 (4318). https://doi.org/10.1038/170177a0. *170*(4318), 177–177.

Kolar, D.R., Kaurin, A., Meule, A., Schlegl, S., Dittmer, N., Voderholzer, U., 2022. Interpersonal, affective and compulsive features of driven exercise in anorexia nervosa. J. Affect. Disord. 307, 53–61. https://doi.org/10.1016/j.jad.2022.03.044.

Laségue, 1873. On hysterical anorexia (a). 1873. Obes. Res. 5 (5), 492–497. https://doi.org/10.1002/J.1550-8528.1997.TB00676.X.

Lehmann, C.S., Hofmann, T., Elbelt, U., Rose, M., Correll, C.U., Stengel, A., Haas, V., 2018. The role of objectively measured, altered physical activity patterns for body mass index change during inpatient treatment in female patients with anorexia nervosa. J. Clin. Med. 7 (9). https://doi.org/10.3390/JCM7090289.

Matthews, A., Lin, J., Jhe, G., Peters, T., Sim, L., Hebebrand, J., 2024. Differentiating anorexia nervosa and atypical anorexia nervosa with absolute weight cut-offs results in a skewed distribution for premorbid weight among youth. Int. J. Eat. Disord. 57 (4), 983–992. https://doi.org/10.1002/EAT.24188.

Maurel, L., MacKean, M., Lacey, J.H., 2024. Factors predicting long-term weight maintenance in anorexia nervosa: a systematic review. Eat. Weight Disord. : EWD 29 (1). https://doi.org/10.1007/S40519-024-01649-5.

Miller, M.N., Pumariega, A.J., 2001. Culture and eating disorders: a historical and cross-cultural review. Psychiatry 64 (2), 93–110. https://doi.org/10.1521/PSYC.64.2.93.18621.

Milos, G., Antel, J., Kaufmann, L.K., Barth, N., Koller, A., Tan, S., Wiesing, U., Hinney, A., Libuda, L., Wabitsch, M., von Känel, R., Hebebrand, J., 2020. Short-term metreleptin treatment of patients with anorexia nervosa: rapid on-set of beneficial cognitive, emotional, and behavioral effects. Transl. Psychiatry 10 (1), 1–10. https://doi.org/10.1038/S41398-020-00977-1. SUBJMETA=476,648,692,699,706; KWRD=PSYCHIATRIC+DISORDERS,SCIENTIFIC+COMMUNITY.

Moskowitz, L., Weiselberg, E., 2017. Anorexia Nervosa/Atypical Anorexia nervosa. Curr. Probl. Pediatr. Adolesc. Health Care 47 (4), 70–84. https://doi.org/10.1016/J.CPPEDS.2017.02.003.

Neale, J., Hudson, L.D., 2020. Anorexia nervosa in adolescents. Br. J. Hosp. Med. 81 (6). https://doi.org/10.12968/HMED.2020.0099.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., et al., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. PLoS Med. 18 (3). https://doi.org/10.1371/JOURNAL.PMED.1003583.

Paquet, J., Kawinska, A., Carrier, J., 2007. Wake detection capacity of actigraphy during sleep. Sleep 30 (10), 1362. https://doi.org/10.1093/SLEEP/30.10.1362.

Paslakis, G., Fauck, V., Röder, K., Rauh, E., Rauh, M., Erim, Y., 2017. Virtual reality jogging as a novel exposure paradigm for the acute urge to be physically active in patients with eating disorders: implications for treatment. Int. J. Eat. Disord. 50 (11), 1243–1246. https://doi.org/10.1002/EAT.22768.

Pjetri, E., de Haas, R., de Jong, S., Gelegen, C., Oppelaar, H., Verhagen, L.A.W., Eijkemans, M.J.C., Adan, R.A., Olivier, B., Kas, M.J., 2012. Identifying predictors of activity based anorexia susceptibility in diverse genetic rodent populations. PLoS One 7 (11). https://doi.org/10.1371/JOURNAL.PONE.0050453.

Rizk, M., Mattar, L., Kern, L., Berthoz, S., Duclos, J., Viltart, O., Godart, N., 2020. Physical activity in eating disorders: a systematic review. Nutrients 12 (1), 183. https://doi.org/10.3390/nu12010183.

Schlegl, S., Dittmer, N., Hoffmann, S., Voderholzer, U., 2018. Self-reported quantity, compulsiveness and motives of exercise in patients with eating disorders and healthy controls: differences and similarities. J. Eat. Disord. 6 (1). https://doi.org/10.1186/S40337-018-0202-6.

Stengel, A., Haas, V., Elbelt, U., Correll, C.U., Rose, M., Hofmann, T., 2017. Leptin and physical activity in adult patients with Anorexia Nervosa: failure to demonstrate a simple linear Association. Nutrients 9 (11). https://doi.org/10.3390/NU9111210.

Sternheim, L., Danner, U., Adan, R., Van Elburg, A., 2015. Drive for activity in patients with anorexia nervosa. Int. J. Eat. Disord. 48 (1), 42–45. https://dx.doi.org/10.1002/eat.22272.

Stults-Kolehmainen, M.A., Blacutt, M., Bartholomew, J.B., Boullosa, D., Janata, P., Koo, B.B., McKee, P.C., Casper, R., Budnick, C.J., Gilson, T.A., Blakemore, R.L., Filgueiras, A., Williamson, S.L., SantaBarbara, N., Barker, J.L., Bueno, F.A., Heldring, J., Ash, G.I., 2022. Urges to move and other motivation states for physical activity in clinical and healthy populations: a scoping review protocol. Front. Psychol. 13, 901272. https://doi.org/10.3389/fpsyg.2022.901272.

Stults-Kolehmainen, M.A., Blacutt, M., Fo gelman, N., Gilson, T.A., Stanforth, P.R., Di vin, A.L., et al., 2021. Measurement of motivation states for physical activity and sedentary behavior: development and validation of the CRAVE scale. Front. Psychol. 12, 568286. https://doi.org/10.3389/Fpsyg.2021.568286.

Taranis, L., Touyz, S., Meyer, C., 2011. Disordered eating and exercise: development and preliminary validation of the compulsive exercise test (CET). Eur. Eat. Disord. Rev. 19 (3), 256–268. https://doi.org/10.1002/ERV.1108.

Vansteelandt, K., Rijmen, F., Pieters, G., Probst, M., Vanderlinden, J., 2007. Drive for thinness, affect regulation and physical activity in eating disorders: a daily life study. Behav. Res. Ther. 45 (8), 1717–1734. https://doi.org/10.1016/j.brat.2006.12.005.

Weiss Roberts, L., Louie, A.K., Rovetto, F., Negri, A.M., 2017. DSM-5. Istruzioni per L'Uso. Raffaello Cortina Editore.

Wells, G., Wells, G., Shea, B., Shea, B., O'Connell, D., Peterson, J., Welch, Losos, M., Tugwell, P., Ga, S.W., Zello, G., Petersen, J., 2014. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomised Studies in Meta-Analyses.

Wronski, M.L., Bernardoni, F., Bahnsen, K., Seidel, M., Arold, D., Doose, A., Steinhäuser, J.L., Borucki, K., Breithaupt, L., Lawson, E.A., Holsen, L.M., Weidner, K., Roessner, V., King, J.A., Plessow, F., Ehrlich, S., 2024. Dynamic Amygdala nuclei alterations in relation to weight status in Anorexia Nervosa are mediated by Leptin. Journal of the American Academy of Child and Adolescent Psychiatry 63 (6), 624–639. https://doi.org/10.1016/j.jaac.2023.08.015.

Wronski, M.L., Gronow, F., Schlömer, J., Bernardoni, F., Geisler, D., Doose, A., Arold, D., Schwanke, N., Ludwicki, F., Roessner, V., King, J.A., Ehrlich, S., 2025. Structural alterations of thalamic nuclei and their associations with leptin levels in patients with anorexia nervosa. Prog. Neuro Psychopharmacol. Biol. Psychiatr. 136. https://doi.org/10.1016/J.PNPBP.2025.111248.

Wronski, M.L., Hohnemann, C., Bernardoni, F., Bahnsen, K., Doose, A., Arold, D., Borucki, K., Holsen, L.M., Lawson, E.A., Plessow, F., Weidner, K., Roessner, V., Diestel, S., King, J.A., Seidel, M., Ehrlich, S., 2023. Explicating the role of amygdala substructure alterations in the link between hypoleptinemia and rumination in anorexia nervosa. Acta Psychiatr. Scand. 148 (4), 368–381. https://doi.org/10.1111/ACPS.13607.

Young, S., Touyz, S., Meyer, C., Arcelus, J., Rhodes, P., Madden, S., Pike, K., Attia, E., Crosby, R.D., Wales, J., Hay, P., 2017. Validity of exercise measures in adults with anorexia nervosa: The EDE, compulsive exercise test and other self-report scales. Int. J. Eat. Disord. 50 (5), 533–541. https://dx.doi.org/10.1002/eat.22633.