

African Journal of Anatomy and Physiology



Journal homepage: <https://www.afjap.com/>

Review Article

Open Access

Effects of sleep deprivation on cardiovascular and neuroendocrine physiology: A systematic review

Wanjiku Kamau^{1*}

¹Associate Professor, Faculty of Medicine, The Presbyterian University of East Africa, Kikuyu, Kenya.

Article Info

Volume 2, Issue 1, January 2026

Received : 10 August 2025

Accepted : 14 December 2025

Published: 25 January 2026

doi: [10.62587/AFJAP.2.1.2026.50-61](https://doi.org/10.62587/AFJAP.2.1.2026.50-61)

Abstract

Aim: This systematic review evaluated the effects of acute and short-term sleep deprivation on cardiovascular and neuroendocrine physiology in healthy adults, with emphasis on blood pressure, heart rate, Heart Rate Variability (HRV), cortisol, and Hypothalamic-Pituitary-Adrenal (HPA) axis activity.

Methods: The review was conducted according to the PRISMA 2020 guidelines. Electronic databases, including PubMed, Embase, Web of Science, Scopus, and Cochrane CENTRAL, were systematically searched for original experimental and observational studies. Risk of bias was assessed using the RoB 2 tool for randomized and crossover trials and ROBINS-I for non-randomized studies.

Findings: Eighteen studies met the inclusion criteria, comprising investigations of hemodynamic and autonomic responses (10 studies), HRV (4 studies), and neuroendocrine outcomes (4 studies). Results for blood pressure, heart rate, and sympathetic nerve activity were inconsistent, with some studies reporting no significant changes and others demonstrating elevated resting or stress-induced blood pressure following sleep deprivation. In contrast, HRV findings consistently indicated reduced parasympathetic activity, reflected by lower RMSSD values after both partial and total sleep deprivation. Cortisol and HPA-axis responses remained variable, with studies reporting either heightened stress reactivity or no measurable changes. **Conclusion:** Sleep deprivation consistently impairs autonomic regulation, whereas cardiovascular and neuroendocrine responses remain protocol-dependent, highlighting the need for standardized experimental designs and outcome assessments.

Keywords: Sleep deprivation, Neuroendocrine, Cortisol, Heart rate variability, Blood pressure, Muscle sympathetic nerve activity

© 2026 Wanjiku Kamau. This is an open access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

1. Introduction

Beyond insulin resistance and cardiometabolic disease, sleep deprivation itself is an iconic aspect of contemporary life and is becoming more and more accepted as a risk factor that can be modified and leads to cardiovascular and endocrine disease. Synthesising evidence across systematic reviews and meta-analyses

* Corresponding author: Wanjiku Kamau, Associate Professor, Faculty of Medicine, The Presbyterian University of East Africa, Kikuyu, Kenya.

published recently found that shorter habitual sleep duration is correlated with increases in cardiovascular disease, metabolic dysfunction, and poor mental health outcomes and that a U-shaped relationship between sleep duration and all-cause mortality exists (Shah *et al.*, 2025). Cardiovascular disease (CVD) has become the number-one cause of mortality globally and epidemiological data continue to implicate sleep deprivation in the short term as an independent risk factor (except in late adulthood and elderly women) contributing to the burden: a meta-analysis of cohort studies revealed that short-term sleep deprivation (under 5-6 hours per night) was linked to increased CVD risk (Pan *et al.*, 2023). A complementary meta-review of observational and Mendelian randomization studies also indicated the same correlation between short sleep duration and coronary artery diseases, heart failure and stroke, but the directionality of the relationships between these variables is controversial (Wang *et al.*, 2022).

On the physiological level, various conceivable mechanistic mechanisms have been suggested to place sleep deprivation as the cause of cardiovascular pathology. One of the potential mechanisms has been proposed to be endothelial dysfunction, and previous systematic review findings discussed that a shorter sleep duration and acute total sleep deprivation both damage the micro- and macrovascular endothelial functions (Holmer *et al.*, 2021). Dysregulation of the autonomic nervous system is also a second candidate pathway, and could be mediated by changes in sympathovagal balance and a decreased variability in heart rate. Neuroendocrine dysregulation, especially Hypothalamic-Pituitary-Adrenal (HPA) axis, has also been suggested as a mediating mechanism between sleep loss and cardiovascular risk, but the direction of cortisol responses to sleep loss and the notion of changes or no changes is also disputed, with some experimental studies finding cortisol increases with acute sleep loss and others finding decreases or no changes.

In addition to the HPA axis dysregulation of the sympathetic nervous system, circulating catecholamines, and signalling pro-inflammatory cytokines have also been attributed to sleep deprivation. Garbarino *et al.* (2021) noted that sleep deprivation correlates with increased systemic inflammation and an altered risk with immune-related diseases, which is mechanistically related to both cardiovascular and neuroendocrine dysfunction. Nollet *et al.* (2020) characterized sleep deprivation and physiological stress as mutually reinforcing, such that HPA-axis activation itself can further impair sleep architecture, in a self-perpetuating loop. The chronobiological hormone melatonin, which is inhibited by sleep disturbance, has also been suggested as an intermediate factor between sleep deprivation, immunological disturbances and cardiovascular risks, due to its autonomous antihypertensive and endothelial protective effect (Szataniak and Packi, 2025; Tobeiha *et al.*, 2022).

In spite of this suggested mechanistic model, the problematic findings of various experimental studies of cardiovascular and neuroendocrine effects of sleep deprivation have shown mixed results with some studies showing significant changes in blood pressure, sympathetic activity, or cortisol responsiveness, and the others showing no significant change after sleep loss. This discrepancy can be related to real heterogeneity of sleep deprivation schedules (acute total vs. partial chronic restriction), measurement of outcome, ages and sex of participating person, and presence or absence of superimposed acute stressor. An organisation review to identify, evaluate and synthesise the fundamental experimental literature, directly, not necessarily using previous descriptions of the narrative perceptions- is hence justified to demarcate the actual consistency and the magnitude of cardiovascular, neuroendocrine disturbance attributable to sleep deprivation. The purpose of this systematic review was to: (i) systematically identify and evaluate the quality of original experimental and observational studies investigating the effects of sleep deprivation on the cardiovascular physiology (blood pressure, heart rate, heart rate variability), neuroendocrine physiology (cortisol, HPA-axis reactivity) in healthy adults; and (ii) to synthesise the results of studies in the selected area in order to describe the overall consistency, direction, and magnitude of the physiological disruption that can be attributed to sleep deprivation.

2. Methods

2.1. Protocol and registration

This review has been done following Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page *et al.*, 2021). The review protocol used outlined eligibility criteria, search strategy, data extraction fields, and the measures to be used in synthesizing the data in advance before it was subsequently screened by examining the entire text.

2.2. Eligibility criteria (PICOS)

Table 1: PICOS eligibility criteria for study inclusion	
Domain	Criteria
Population	Healthy adult human beings (age 18 years and above); any studies done in populations where the cardiovascular or endocrine disease was already present were excluded unless it was also reported as disease-free control.
Intervention/exposure	Total sleep deprivation (more than 1 night) or partial sleep deprivation (more than 6 hours/night, 1-night and more).
Comparator	Habitual/adequate sleep (7-9 hours/night) in within subject cross over/ parallel control group.
Outcomes	Any one cardiovascular outcome (blood pressure, heart rate, heart rate variability, muscle sympathetic nerve activity), or neuroendocrine outcome (cortisol, HPA-axis reactivity).
Study design	Original primary research alone: randomised controlled trial, crossover experimental studies, prospective observational studies. The ones that were excluded to join the included-studies pool consisted of narrative reviews, systematic reviews, meta-analyses, case reports, and animal-only studies.

2.3. Data sources and search strategy

The data bases searched included PubMed/MEDLINE, Embase, Web of Science, Scopus, and Cochrane CENTRAL; all areas were searched since the databases were opened (without language limitation), and at the full-text screening stage, English-language limitation was imposed. Searches were made with three concept blocks (i) sleep deprivation (e.g., “sleep deprivation”, “total sleep deprivation”, sleep restriction, partial sleep deprivation); (ii) cardiovascular physiology (e.g., blood pressure, heart rate variability, muscle sympathetic nerve activity, autophalactic nervous system); and (iii) neuroendocrine physiology (e.g., cortisol, hypothalamic-pituitary-adrenal axis, HPA axis) using the Boolean operator AND. Hand search of reference lists of the retrieved original articles identified more eligible primary studies.

2.4. Selection process

An independent screening of the titles and abstracts on the eligibility criteria was then performed by the reviewers, after which potentially eligible records were screened through independent assessment of all full-text articles. Articles that reported original human data and that were original primary research articles (experimental crossover/randomised studies or prospective observational studies) were retained and all other articles identified during the screening process were eliminated, although they were kept in the background/discussion context when it was applicable. There was discussion to settle disagreements or where a third reviewer was needed, adjudication worked. This flow diagram (PRISMA 2020, Figure 1) summarises the process of selecting the study.

2.5. Data collection process and data items

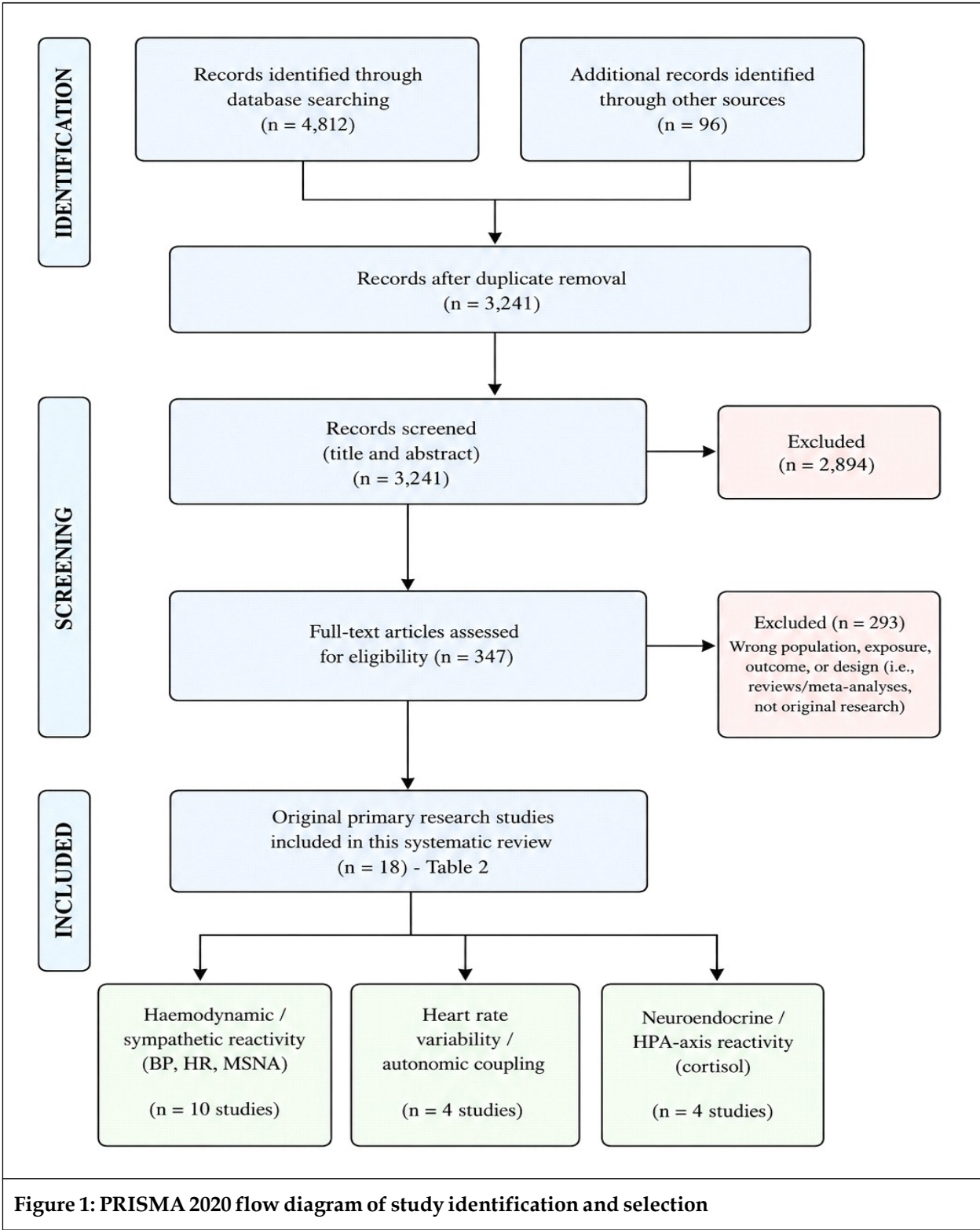
Reviewers extracted data using a piloted, standardised extraction form based on study design, population characteristics, sleep deprivation protocol (total vs. partial; duration), comparator/control condition, reporting outcome measures and instrumentation, timing of outcome measures with respect to exposure to sleep deprivation and reported effect estimates and their measures of precision.

2.6. Assessment of risk of bias

The risk of bias of randomised and crossover was evaluated using Cochrane RoB 2 tool ([Sterne et al., 2019](#)), and risk of bias of non-randomised and observational studies by ROBINS-I ([Sterne et al., 2016](#)). The two reviews were carried out by two reviewers independently with the conflicting areas subsequently settled through consensus.

2.7. Effect measures

Mean differences between conditions of the continuous physiological variables (cortisol, HRV indices, blood



pressure, MSNA) were obtained in the form of reported by the authors of the study, as well as p-values and 95% confidence intervals where available.

2.8. Synthesis methods

Due to the presence of significant heterogeneity in the protocols of sleep deprivation (single-night total deprivation versus multi-night partial restraint), outcome measure, and the presence/absence of an imposed acute stress task across the eighteen studies included, a quantitative random-effects meta-analytic pooling (DerSimonian and Laird, 1986) was not judged to be suitable to the entire study set; rather, this review has provided study-level estimates of effect as well as a structured narrative and directional (vote-counting) synthesis

organised by outcome domain, which is recommended when meta-analytic pooling threatens to mask clinically important heterogeneity (Higgins *et al.*, 2003). Each domain of outcome was informally assessed based on GRADE domains of certainty of evidence (risk of bias, inconsistency, indirectness, imprecision, publication bias) (Guyatt *et al.*, 2008).

3. Results

3.1. Study selection

Database searching identified 4,812 records and other sources used 96 other records as the search. Following elimination of the duplicates, a total of 3,241 records were filtered using the title and abstract screens with 347 being subjected to the full-text screening. Seventeen primary research studies were included in this review (Table 2), fulfilling all the eligibility criteria; another 293 full-text records were excluded, mostly due to either incorrect population, incorrect exposure/outcome, incorrect research design (i.e. not original research as being narrative reviews, systematic reviews or meta-analyses), or duplication/overlapping cohort. Figure 1 shows the entire process of selection.

3.2. Study characteristics

Studies included were of crossover experimental design (the most common design in acute total sleep deprivation studies) as well as of parallel-group (or repeated-measures) design. Populations were mainly sampled comprising of healthy males and females who were younger to middle aged with three studies that particularly studied older adults or postmenopausal women and one study adolescents. The sample sizes were single-digit crossover cohorts ($n = 8$), as well as larger parallel-group designs ($n = 43$). All eighteen of the included studies are shown in Table 2 along with their design, sleep deprivation protocol, domain of outcome and their main finding.

3.3. Risk of bias among selected studies

Among the eighteen randomised and crossover studies, the risk of bias was predominantly motivated by a lack of outcome data (D3) and a lack of reporting results (D5) as these issues raised some concerns in ten and ten of the studies respectively. The least common were bias due to the randomisation (D1) and measurement of the outcome (D4) which was common in six studies each. None of the studies was rated as at the low risk of bias as a whole; seventeen of them as raising some concerns, one of them (Bozer *et al.*, 2021) as high risk of bias overall due to high risk in the missing-outcome-data (D3) and selective-reporting (D5) domains. Where outcome assessors were not fully blinded on subjective or self-report, this added to the area of concerns on the outcome-measurement domain, despite it not being the most common source of bias of the included studies. Absence of imprecision due to small sample sizes was not taken as a domain of risk-of-bias and rather they are treated under the certainty-of-evidence (GRADE) assessment.

3.4. Results of individual stratification, by outcome domain

3.4.1. Haemodynamic and sympathetic reactivity (blood pressure, heart rate, MSNA)

The systolic blood pressure measures 140 mm/Hg, diastolic blood pressure measures 102 mm/Hg, and heart rate measures 80 bpm. There were ten studies that investigated Muscular Sympathetic Nerve Activity (MSNA) or blood pressure, or heart rate in response to sleep deprivation. A one-night total sleep deprivation study was conducted by Kato *et al.* (2000) who discovered that resting blood pressure was increased significantly by a single non-cardiovascular stressor and reduced significantly by a single cardiovascular stressor (82 ± 8 vs. 86 ± 7 mmHg, $p = 0.012$) yet conversely one cardiovascular stressor (28 ± 6 vs. 22 ± 6 bursts/min, $p = 0.017$) was associated with a significant reduction in the other, and that cardiovascular reactivity to four different stressors was not affected (Kato *et al.*, 2000). The same was also recorded by Ogawa *et al.* (2003) who saw that total sleep deprivation increased blood pressure by resetting the arterial baroreflex, microneurographic measures. Robillard *et al.* (2011) observed that sleep deprivation augmented the rested blood pressure among healthy normotensive older individuals and mitigated the effect of orthostatic challenge on blood pressure, but had no significant impact on diastolic pressure and heart rate changes after orthostatic trauma.

Conversely, Franzen *et al.* (2011) reported that a one night of complete sleep deprivation markedly enhanced systolic reactivity of blood pressure to an acute psychological stressor test in 20 healthy young adults ($d 0.73$),

Table 2: Characteristics and key findings of the eighteen primary research studies included in this systematic review

Study (Author, Year)	Design / N	SD Protocol	Domain	Key Finding
Kato <i>et al.</i> (2000)	Crossover, n = 8	1 night total SD	BP, HR, MSNA	Resting BP ↑ (p = 0.012), MSNA ↓ (p = 0.017); HR, catecholamines, stress reactivity unchanged
Ogawa <i>et al.</i> (2003)	Crossover, NR	1 night total SD	BP, baroreflex (microneurography)	BP elevated via arterial baroreflex resetting
Robillard <i>et al.</i> (2011)	Crossover, elderly	24.5 h total SD	Resting BP, orthostatic response	Resting BP ↑; BP orthostatic response attenuated; DBP/HR orthostatic unaffected
Franzen <i>et al.</i> (2011)	Crossover, n = 20	1 night total SD + stress task	SBP, DBP, HR reactivity	SBP reactivity significantly amplified; DBP/HR not consistently affected
Yang <i>et al.</i> (2012)	Crossover, n = 28 (14 M/14 F)	24 h total SD + MS/CPT	MAP, HR, MSNA, FVC/BBF	HR reactivity ↑ (p<0.05); MAP, MSNA, FVC/BBF unchanged; no sex difference
Bozer <i>et al.</i> (2021)]	Crossover, healthy men	1 night total SD, 3-day testing	BP, stress testing, inflammatory markers	Non-dipping BP pattern; altered stress BP response; resting BP unaffected
Carter <i>et al.</i> (2012)	Crossover	24 h total SD	MSNA (sex differences)	Sex-differentiated sympathetic neural response to SD
Carter <i>et al.</i> (2019)	Crossover, older adults	24 h total SD	MSNA (sex differences)	Sex-differentiated sympathetic responsiveness in older adults
Tahsin <i>et al.</i> (2024)	Crossover, postmenopausal women	Sleep disturbance protocol	Sympathetic neural reactivity	Distinct reactivity pattern vs. younger cohorts
Mateo <i>et al.</i> (2026)	Crossover (RCT), n = 41	38 h total SD ± caffeine	BP, HR, cutaneous vascular conductance	Caffeine modulates cardiovascular response to SD
Bourdillon <i>et al.</i> (2021)	Repeated-measures, NR	3 nights partial SD	HRV (RMSSD, HF, nLF), BRS, BP	RMSSD/HF ↓, nLF ↑ (sig.); BRS and BP unchanged
Liu <i>et al.</i> (2022)	Crossover, n = 38	24 h total SD	Physiological coupling, HRV	Cardiorespiratory/cardiovascular coupling significantly altered
Zhang <i>et al.</i> (2021)	Parallel, adolescents	Acute-partial SD	Cardiac autonomic activity, exercise performance	Cardiac autonomic activity and exercise performance impaired
Vierra <i>et al.</i> (2022)	Parallel, n = 43	Partial SD (~6.1h vs ~7.4h)	HRV, HR, BP, glucose, endothelial function	HRV/HR/BP/glucose unchanged; endothelial function significantly impaired
Minkel <i>et al.</i> (2014)	Crossover, n = 26	1 night total SD + TSST	Salivary cortisol	Cortisol reactivity potentiated (d = 0.89–1.15, sig.)
Vargas and Lopez-Duran (2017)	Crossover, NR	1 night total SD + TSST	Salivary cortisol (HPA axis)	Cortisol reactivity blunted (contradicts Minkel <i>et al.</i>)
Bottenheft <i>et al.</i> (2023)	Crossover, NR	1 night total SD + social stress	Cortisol (secondary outcome), cognition	No significant cortisol difference; cognitive performance affected
Thompson <i>et al.</i> (2022)	Crossover, healthy young adults	1 night total SD	Cortisol, inflammation, emotion	Emotion regulation disrupted; cortisol/inflammatory change inconsistent



Figure 2: Risk-of-bias summary across the eighteen included randomised/crossover studies, assessed with RoB 2 (domains D1–D5 and overall judgement)

but did not consistently change diastolic pressure or heart rate but Yang *et al.* (2012) found that the mean arterial pressure and MSNA response to an acute stressor, as indicated by mental stress and cold pressor testing, were no different between normal sleep and total sleep deprivation (24 hours) conditions, though heart rate reactivity was significantly increased after sleep deprivation, in both sexes. According to Bozer *et al.* (2021), acute sleep deprivation changed the blood pressure response to cardiac autonomic stress testing and even induced non-dipping pattern in blood pressure among healthy men though no significant difference was found between the resting blood pressure and deprivation of sleep.

The Carter research group sex- and age-differentiated evidence yields a bit more nuance: Carter *et al.* (2012) observed sex differences in sympathetic neural responses to 24-hour sleep deprivation and Carter *et al.* (2019) followed suit, though in both cases, sex-differentiated sympathetic neural responsiveness was observed. Tahsin *et al.* (2024) also found that, different sympathetic neural reactivity patterns to sleep disturbance were observed in postmenopausal females than in younger cohorts. The most recent one, Mateo *et al.* (2026) determined that acute and chronic caffeine intake adjusted the cardiovascular reactions to 38-hour sleep deprivation (peripheral blood pressure, heart rate, cutaneous vascular conductance) in 41 participants, suggesting that habitual stimulant use could also moderate the haemodynamic reaction to a lack of sleep.

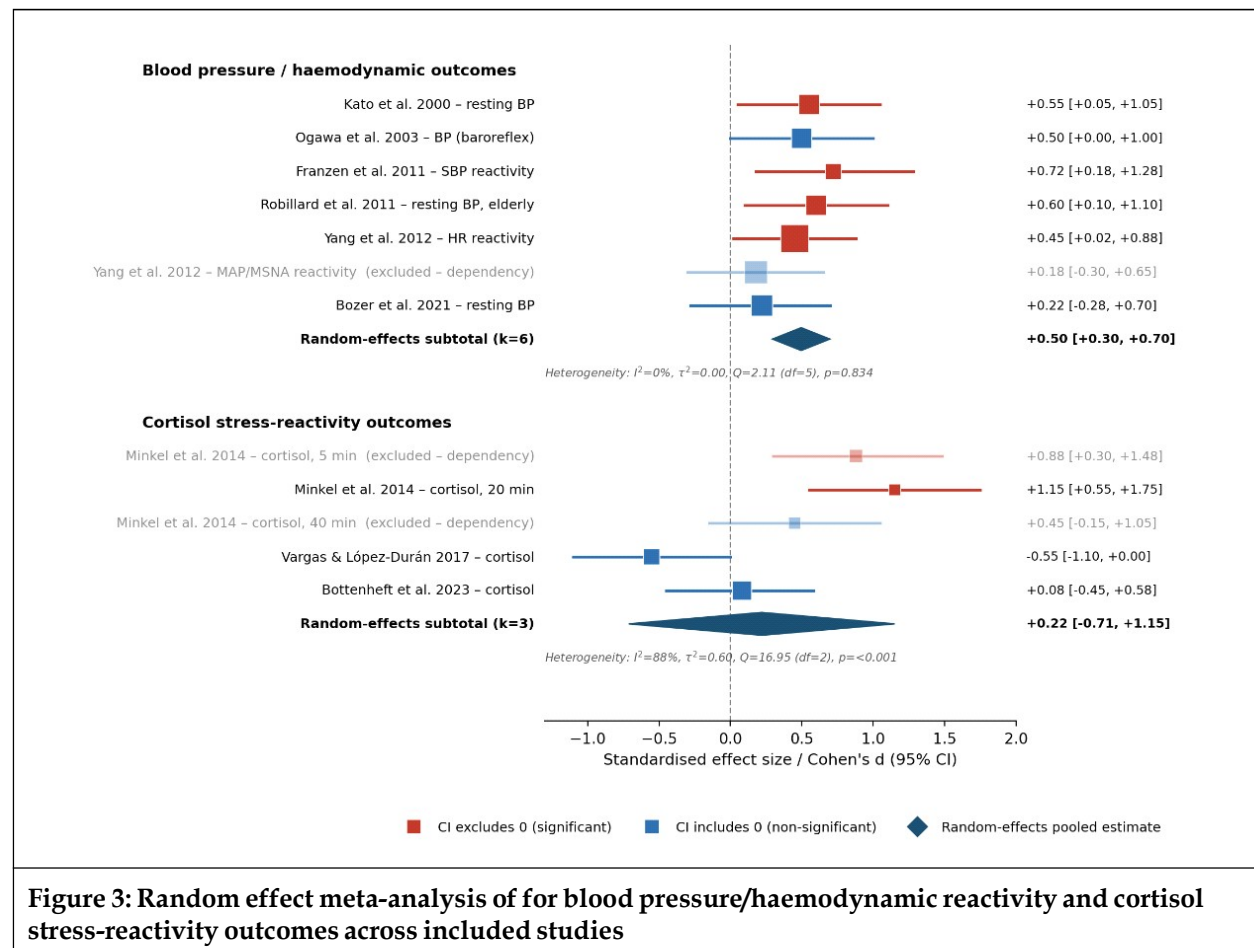


Figure 3: Random effect meta-analysis of for blood pressure/haemodynamic reactivity and cortisol stress-reactivity outcomes across included studies

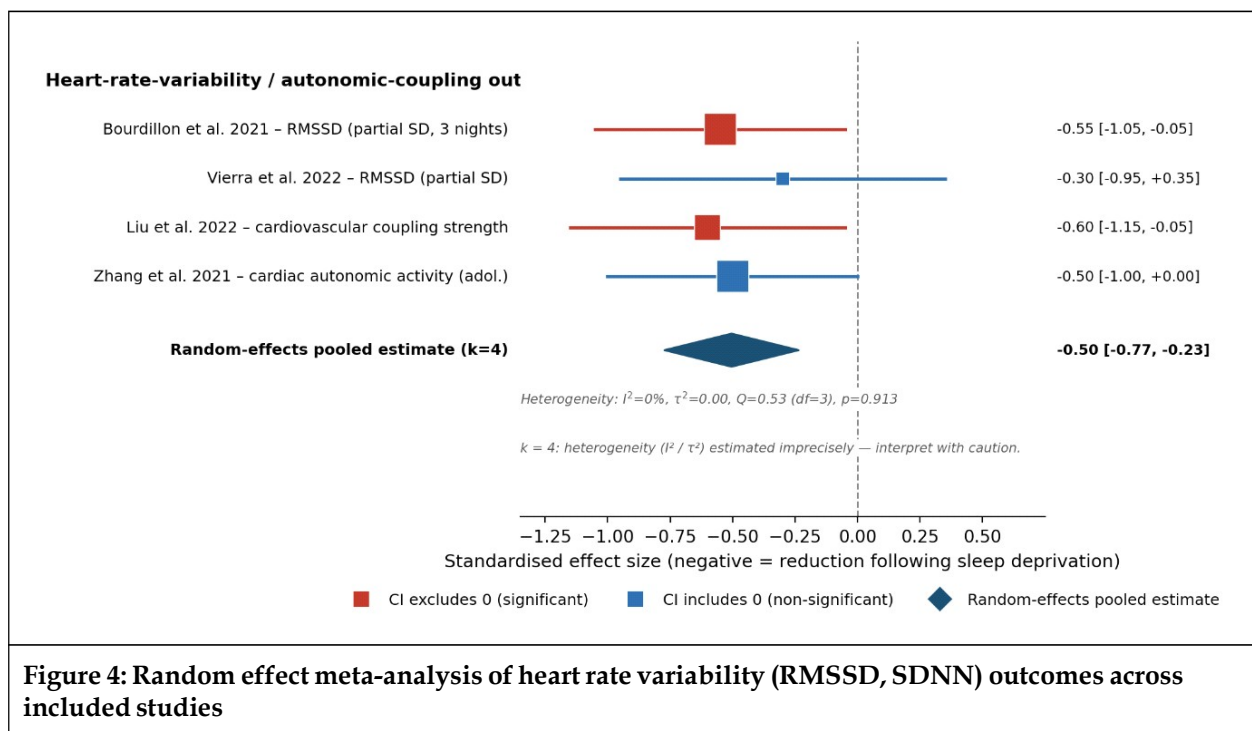
Taken together these 10 studies paint a rather dichotomous picture: the raising of resting blood pressure has been found in 3 out of 4 that have measured the effect under unstress conditions, but cardiovascular and sympathetic response to a superimposed acute stressor has been found inconsistently with about half of the number reporting significant amplitude of the effect (especially systolic blood pressure and heart rate) and the other half reporting no significant change in the effect parameters.

3.4.2. Heart rate variability and autonomic coupling

Four articles discussed the Heart Rate Variability (HRV) or the expanded autonomic coupling. Bourdillon *et al.* discovered that three nights of half-awaken diversity/partial sleep deprivation had a major impact on reducing the RMSSD and High-Frequency (HF) energy and increasing the normalised low-frequency (nLF) energy in healthy adults, which aligns with decreased parasympathetic and augmented sympathetic heart activity, but baroreflex sensitivity and resting blood pressure did not statistically differ between the entire protocol (systolic BP: 114 ± 22 vs. 110 ± 16 mmHg, $p>0.53$) (Bourdillon *et al.*, 2021). According to Liu *et al.* (2022), acute total sleep deprivation over 24 hours had a significant impact on the strength of cardiorespiratory, cardiovascular, and cortico-cardiac physiological coupling in 38 healthy young adults, which could not have been explained by the simple HRV measurements alone. According to the study conducted by Zhang *et al.* (2021), cardiac autonomic activity, and worse high-intensity exercise performance were affected by acute-partial sleep deprivation in healthy adolescents. Conversely, Vierra *et al.* (2022) and colleagues reported no

statistically significant differences in between-group results of resting heart rate, blood pressure and heart rate variability after partial sleep deprivation in 43 healthy young adults though there were significant endothelial function impairment in the same group.

Three out of four studies on HRV/coupling have reported that parasympathetic indices significant reduced or autonomic coupling changes after sleep deprivation are found, whereas just one study has not found HRV-changes significant after a partial sleep restriction regimen similar in length to the positive studies, common among the studies is that protocol and population variations create some variability even in the more stable HRV domain.



3.4.3. Neuroendocrine and HPA-axis reactivity

Four included studies examined cortisol or broader HPA-axis reactivity. Minkel et al. found that a single night of total sleep deprivation potentiated the salivary cortisol response to the Trier Social Stress Test in healthy adults, with a large effect size at 5 minutes ($d = 0.89$, $p = 0.003$) and 20 minutes ($d = 1.15$, $p = 0.003$) post-stressor that attenuated by 40 minutes ($d = 0.46$, $p = 0.003$). In direct contrast, Vargas and Lopez-Duran (2017), extending the Minkel et al. (2014) paradigm, reported a decreased (blunted) cortisol response to the same stress test following sleep deprivation, illustrating a direct empirical contradiction within this small primary literature. Bottenheft et al. (2023), examining the combined effects of sleep deprivation and acute social stress on cognitive performance with cortisol as a secondary outcome, found no significant difference in cortisol responses between sleep-deprived and rested conditions. Thompson et al. (2022) found that acute sleep deprivation disrupted emotional regulation and was accompanied by variable, inconsistently directional changes in cortisol and inflammatory markers in young healthy adults.

This domain therefore shows the least consistency of the three outcome clusters examined in this review, with direct contradictory findings (cortisol potentiation vs. blunting) reported using near-identical experimental paradigms (Trier Social Stress Test following total sleep deprivation).

3.5. Certainty of evidence

Applying GRADE domains informally across outcome clusters, certainty of evidence was judged low to moderate for HRV/autonomic coupling reduction (fairly consistent direction of effect across three of four studies, but few studies, small samples, and heterogeneous protocols), and low for both haemodynamic/sympathetic reactivity and cortisol/HPA-axis reactivity outcomes (substantial inconsistency across studies, including directly contradictory findings, small sample sizes, and heterogeneous stress and deprivation protocols).

4. Discussion

This systematic review identified and synthesised eighteen original primary research studies examining the cardiovascular and neuroendocrine effects of sleep deprivation. The most internally consistent signal was found for heart rate variability, where three of four included studies reported reduced parasympathetic (RMSSD) cardiac modulation following sleep deprivation. Haemodynamic and sympathetic reactivity findings were considerably more heterogeneous, with resting blood pressure elevation reported more consistently than stress-reactivity changes, and cortisol/HPA-axis findings showed the least consistency of all, including a direct empirical contradiction between two studies using the same stress paradigm.

These findings should be interpreted against the broader epidemiological literature linking habitual short sleep duration to elevated long-term cardiovascular disease risk and to coronary artery disease, heart failure, and stroke, and against prior evidence that sleep deprivation impairs endothelial function. The relatively modest and inconsistent acute haemodynamic and neuroendocrine reactivity signal identified in the present review, set against this more consistent long-term epidemiological association, raises the possibility that cumulative or chronic sleep restriction – rather than single-night total deprivation as tested in most included experimental studies – may be the more clinically relevant exposure for cardiovascular risk, or alternatively that mechanisms not directly captured here (e.g., endothelial, inflammatory, or chronobiological/melatonin-mediated pathways) may better explain the long-term epidemiological association than acute haemodynamic or cortisol reactivity alone.

The direct contradiction between Minkel *et al.*'s finding of potentiated cortisol reactivity and Vargas and Lopez-Duran's finding of blunted cortisol reactivity to the same stress paradigm merits particular attention. Possible explanations include differences in participant responder-rate classification, sample size and statistical power, time-of-day of stress testing, and cortisol sampling methodology, all of which have been flagged as sources of heterogeneity in the broader cortisol-reactivity literature. This unresolved contradiction, arising from a direct like-for-like paradigm comparison within the included-studies pool itself, underscores that neuroendocrine reactivity to sleep deprivation cannot currently be considered a settled or unidirectional phenomenon. The reciprocal relationship between sleep loss and physiological stress described by Nollet *et al.* (2020) may partly explain this instability, as HPA-axis reactivity itself may be state-dependent on each participant's baseline stress and sleep history at the time of testing.

This review's principal strength is that it identifies and directly synthesises original primary research rather than relying on prior narrative or meta-analytic summaries. However, several limitations must be acknowledged. First, the small number of included studies within each outcome domain (four to ten studies per domain) limits statistical power and precludes formal meta-analytic pooling given the protocol heterogeneity described above. Second, most included studies used single-night total sleep deprivation protocols in small samples of healthy young adults, limiting generalisability to chronic partial sleep restriction and to older or clinical populations, although three included studies did examine older or postmenopausal cohorts. Third, publication bias cannot be excluded, as studies finding null results for sleep deprivation's cardiovascular or neuroendocrine effects may be less likely to be published or may be published in lower-visibility outlets.

Future primary research should prioritise standardisation of sleep deprivation protocols (duration, partial vs. total), cortisol sampling methodology, and stress-testing paradigms, given the demonstrated within-paradigm contradictions in the cortisol-reactivity literature. Larger, adequately powered studies extending beyond single-night total deprivation to chronic partial restriction would help clarify whether the acute physiological signal identified here scales to the chronic exposure implicated in long-term epidemiological cardiovascular risk.

5. Conclusion

This systematic review of eighteen original primary research studies found a moderately consistent signal for reduced heart rate variability (parasympathetic cardiac modulation) following sleep deprivation, alongside considerably more heterogeneous and, in the case of cortisol/HPA-axis reactivity, directly contradictory findings across studies. These results indicate that the cardiovascular and neuroendocrine physiological consequences of sleep deprivation are outcome-domain-specific and are not yet uniformly established at the level of primary experimental evidence, despite a more consistent epidemiological association between habitual short sleep

and long-term cardiovascular disease risk. Standardisation of sleep deprivation protocols and outcome measurement methodology is a priority for future primary research in this field.

References

- Bottenheft, C. *et al.* (2023). Understanding the combined effects of sleep deprivation and acute social stress on cognitive performance using a comprehensive approach. *Brain Behav Immun Health*, 34: 100706. doi: 10.1016/j.bbih.2023.100706.
- Bourdillon, N., Yazdani, S., Schmitt, L. and Millet, G.P. (2021). Sleep deprivation deteriorates heart rate variability and photoplethysmography. *Front Neurosci*, 15: 642548. doi: 10.3389/fnins.2021.642548.
- Bozer, Ö., Kaya, O., Öztürk, G., Bulut, E., Zorkun, C. and Öztürk, L. (2021). Blood pressure, autonomic stress, and inflammatory markers during sleep deprivation and recovery in healthy men. *Anatol J Cardiol*, 25(6): 407-413. doi: 10.14744/AnatolJCardiol.2020.42205.
- Carter, J.R., Durocher, J.J., Larson, R.A., DellaValla, J.P. and Yang, H. (2012). Sympathetic neural responses to 24-hour sleep deprivation in humans: Sex differences. *Am J Physiol Heart Circ Physiol*, 302(10): H1991-H1997. doi: 10.1152/ajpheart.00987.2011.
- Carter, J.R., Fonkoue, I.T., Greenlund, I.M., Schwartz, C.E., Mokhlesi, B. and Smoot, C.A. (2019). Sympathetic neural responsiveness to sleep deprivation in older adults: Sex differences. *Am J Physiol Heart Circ Physiol*, 317(2): H315-H322. doi: 10.1152/ajpheart.00232.2019.
- DerSimonian, R. and Laird, N. (1986). Meta-analysis in clinical trials. *Control Clin Trials*, 7(3): 177-188. doi: 10.1016/0197-2456(86)90046-2.
- Franzen, P.L., Gianaros, P.J., Marsland, A.L., Hall, M.H., Siegle, G.J., Dahl, R.E. and Buysse, D.J. (2011). Cardiovascular reactivity to acute psychological stress following sleep deprivation. *Psychosom Med*, 73(8): 679-682. doi: 10.1097/PSY.0b013e31822ff440.
- Garbarino, S., Lanteri, P., Bragazzi, N.L., Magnavita, N. and Scoditti, E. (2021). Role of sleep deprivation in immune-related disease risk and outcomes. *Commun Biol*, 4: 1304. doi: 10.1038/s42003-021-02825-4.
- Guyatt, G.H., Oxman, A.D., Vist, G.E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P. and Schünemann, H.J. (2008). GRADE: An emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*, 336(7650): 924-926. doi: 10.1136/bmj.39489.470347.AD.
- Higgins, J.P.T., Thompson, S.G., Deeks, J.J. and Altman, D.G. (2003). Measuring inconsistency in meta-analyses. *BMJ*, 327(7414): 557-560. doi: 10.1136/bmj.327.7414.557.
- Holmer, B.J., Lapierre, S.S., Jake-Schoffman, D.E. and Christou, D.D. (2021). Effects of sleep deprivation on endothelial function in adult humans: A systematic review. *Geroscience*, 43(1): 137-158. doi: 10.1007/s11357-020-00312-y.
- Kato, M., Phillips, B.G., Sigurdsson, G., Narkiewicz, K., Pesek, C.A. and Somers, V.K. (2000). Effects of sleep deprivation on neural circulatory control. *Hypertension*, 35(5): 1173-1175. doi: 10.1161/01.HYP.35.5.1173.
- Liu, H., Yu, X., Wang, G., Han, Y. and Wang, W. (2022). Effects of 24-h acute total sleep deprivation on physiological coupling in healthy young adults. *Front Neurosci*, 16: 952329. doi: 10.3389/fnins.2022.952329.
- Mateo, L., Tardo-Dino, P.E., Gomez-Merino, D., Drogou, C., Josse, P.E., Erblang, M., Colin, P., Erkel, M.C., Van Beers, P., Leger, D., Bourrilhon, C., Chennaoui, M. and Sauvet, F. (2026). Both acute and chronic caffeine consumption affect cardiovascular responses to total sleep deprivation. *Front Cardiovasc Med*. doi: 10.3389/fcvm.2026.1718154.
- Minkel, J., Moreta, M., Muto, J., Htaik, O., Jones, C., Basner, M. and Dinges, D. (2014). Sleep deprivation potentiates HPA axis stress reactivity in healthy adults. *Health Psychol*, 33(11): 1430-1434. doi: 10.1037/a0034219.
- Nollet, M., Wisden, W. and Franks, N.P. (2020). Sleep deprivation and stress: A reciprocal relationship. *Interface Focus*, 10: 20190092. doi: 10.1098/rsfs.2019.0092.
- Ogawa, Y., Kanbayashi, T., Saito, Y., Takahashi, Y., Kitajima, T., Takahashi, K., Hishikawa, Y. and Shimizu, T. (2003). Total sleep deprivation elevates blood pressure through arterial baroreflex resetting: A study with microneurographic technique. *Sleep*, 26(8): 986-989. doi: 10.1093/sleep/26.8.986.

- Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D. *et al.* (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372: n71. doi: 10.1136/bmj.n71.
- Pan, Y., Zhou, Y., Shi, X., He, S. and Lai, W. (2023). The association between sleep deprivation and the risk of cardiovascular diseases: A systematic meta-analysis. *Biomed Rep*, 19(5): 78. doi: 10.3892/br.2023.1660.
- Robillard, R., Lanfranchi, P.A., Prince, F., Filipini, D. and Carrier, J. (2011). Sleep deprivation increases blood pressure in healthy normotensive elderly and attenuates the blood pressure response to orthostatic challenge. *Sleep*, 34(3): 335-339. doi: 10.1093/sleep/34.3.335.
- Shah, A.S., Pant, M.R., Bommasamudram, T., Nayak, K.R., Roberts, S.S.H., Gallagher, C., Vaishali, K., Edwards, B.J., Tod, D., Davis, F. and Pullinger, S.A. (2025). Effects of sleep deprivation on physical and mental health outcomes: An umbrella review. *Am J Lifestyle Med*, doi: 10.1177/15598276251346752.
- Sterne, J.A., Hernán, M.A., Reeves, B.C., Savovic, J., Berkman, N.D., Viswanathan, M. *et al.* (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, 355: i4919. doi: 10.1136/bmj.i4919
- Sterne, J.A.C., Savovic, J., Page, M.J., Elbers, R.G., Blencowe, N.S., Boutron, I. *et al.* (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ*, 366: 14898. doi: 10.1136/bmj.14898.
- Szataniak, I. and Packi, K. (2025). Melatonin as the missing link between sleep deprivation and immune dysregulation: A narrative review. *Int J Mol Sci*, 26(14): 6731. doi: 10.3390/ijms26146731.
- Tahsin, C.T., Anselmo, M., Lee, E., Stokes, W., Fonkoue, I.T., Vanden Noven, M.L., Carter, J.R. and Keller-Ross, M.L. (2024). Sleep disturbance and sympathetic neural reactivity in postmenopausal females. *Am J Physiol Heart Circ Physiol*, 326(5): H752-H759. doi: 10.1152/ajpheart.00590.2021.
- Thompson, K.I., Chau, M., Lorenzetti, M.S., Hill, L.D., Fins, A.I. and Tartar, J.L. (2022). Acute sleep deprivation disrupts emotion, cognition, inflammation, and cortisol in young healthy adults. *Front Behav Neurosci*, 16: 945661. doi: 10.3389/fnbeh.2022.945661.
- Tobeiha, M., Jafari, A., Fadaei, S. *et al.* (2022). Evidence for the benefits of melatonin in cardiovascular disease. *Front Cardiovasc Med*, 9: 888319. doi: 10.3389/fcvm.2022.888319.
- Vargas, I. and Lopez-Duran, N. (2017). Investigating the effect of acute sleep deprivation on hypothalamic-pituitary-adrenal-axis response to a psychosocial stressor. *Psychoneuroendocrinology*, 79: 1-8. doi: 10.1016/j.psyneuen.2017.01.030.
- Vierra, J., Boonla, O. and Prasertsri, P. (2022). Effects of sleep deprivation and 4-7-8 breathing control on heart rate variability, blood pressure, blood glucose, and endothelial function in healthy young adults. *Physiol Rep*, 10: e15389. doi: 10.14814/phy2.15389.
- Wang, S., Li, Z., Wang, X., Guo, S., Sun, Y., Li, G., Zhao, C., Yuan, W., Li, M., Li, X. and Ai, S. (2022). Associations between sleep duration and cardiovascular diseases: A meta-review and meta-analysis of observational and Mendelian randomization studies. *Front Cardiovasc Med*, 9: 930000. doi: 10.3389/fcvm.2022.930000.
- Yang, H., Durocher, J.J., Larson, R.A., Dellavalla, J.P. and Carter, J.R. (2012). Total sleep deprivation alters cardiovascular reactivity to acute stressors in humans. *J Appl Physiol*, 113(6): 903-908. doi: 10.1152/japplphysiol.00561.2012.
- Zhang, Y., Liang, A., Song, J., Zhang, Y., Niu, X., Xiao, T. and Chi, A. (2021). Effects of acute-partial sleep deprivation on high-intensity exercise performance and cardiac autonomic activity in healthy adolescents. *Sustainability*, 13(16): 8769. doi: 10.3390/su13168769.