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AUGUST 2025

THE IMPACT OF SLEEPWEAR TEXTILES

Polyester vs. Linen

A CONTROLLED SINGLE-SUBJECT CROSSOVER STUDY

The Impact of Sleepwear Textiles (Polyester vs. Organic Linen) on Sleep Quality and Recovery

A Controlled Single-Subject Crossover Study

Study Duration: June 5, 2025 – August 2, 2025

Abstract

Although the objective differences did not reach statistical significance ($p > 0.05$), the overall trends clearly favored organic linen across nearly all parameters. **Total sleep time increased by +5.26%,** reflecting a moderate effect size (Cohen's $d = 0.65$), while **REM sleep duration rose by +7.1%**, indicating enhanced restorative sleep. **Sleep latency was reduced by 31.8%,** pointing to faster sleep onset. Additionally, resting heart rate decreased by 1.7% and heart rate variability improved slightly (+0.9%), suggesting more efficient autonomic recovery during the linen phase.

However, the subjective outcomes revealed even stronger effects. **Fabric comfort increased dramatically** (Cohen's $d = 5.85$), and **sleep quality, morning mood, and emotional calm all improved with large to very large effect sizes** ($d = 2.46–3.46$). **PSQI scores decreased steadily** throughout the linen phase, suggesting accumulating benefits over time.

In addition to these quantifiable results, the study was also shaped by lived experience. During the polyester phase, the participant noted recurring headaches, abdominal cramps, and a sensation of internal heat upon waking, symptoms absent during the linen phase. Notably, the menstrual cycle, which had previously been highly regular, was delayed by three days during the polyester intervention. While anecdotal, these physiological disruptions **raise important questions regarding the potential endocrine-disrupting properties of synthetic fibers,** especially when worn in prolonged dermal contact overnight.

Together, these findings indicate that organic linen sleepwear may offer measurable benefits for both physiological and perceptual dimensions of sleep. Further studies in larger, randomized cohorts are recommended to validate these promising early results with additional blood testing.

Hypothesis

Wearing organic linen will result in higher REM sleep and HRV, lower resting heart rate, increased perceived restfulness, fewer night awakenings, and deeper thermal and emotional regulation. Because natural fibers like linen carry a frequency (~5000 Hz)[1] and have documented compatibility with the skin barrier and circadian temperature rhythms.

1.Introduction

Textiles worn during sleep may significantly influence thermophysiological regulation and tactile comfort, which in turn can affect sleep quality and recovery processes. While considerable emphasis has been placed on optimizing external sleep environments, such as light, sound, and temperature, sleepwear remains an understudied variable.

The human skin, the body's largest organ, is in continuous contact with sleepwear for approximately one-third of a lifetime. As such, the properties of these textiles, including breathability, moisture wicking, insulation, and chemical content, warrant closer investigation. Inadequate or poor sleep has been associated with detrimental effects on cognitive and motor performance, emotional regulation, and disruptions in metabolic, hormonal, and immune systems.

Polyester, a synthetic fiber derived from petroleum, is engineered through polymerization and extrusion processes that involve multiple chemical treatments (plasticizers, anti-wrinkle agents, antimicrobial coatings, dyes). These substances may leach under warm and humid conditions and interact with the skin barrier.

Polyester's low moisture absorbency and high thermal insulation are also known to impair the body's nocturnal cooling mechanisms[2].

In contrast, linen fiber is derived from the flax plant and undergoes mechanical retting and scutching in its organic form, free of added chemicals. Linen is highly breathable, exhibits rapid moisture vapor transmission, and has low surface friction, making it ideal characteristics for thermal regulation during sleep[3]. Historically, linen has been used for wound care, due to its antimicrobial and absorbent properties, and was the fabric of choice for ancient Egyptian pharaohs' burial garments, suggesting both physiological and symbolic significance[1]. Modern studies also report that bedridden patients do not develop pressure sores as quickly on linen sheets compared to synthetic fabrics, likely due to its superior thermoregulation and microcirculatory support[1]. Furthermore, linen has been shown to emit a resonant frequency of ~5000 Hz, far higher than synthetic materials like polyester (which resonate near 0 Hz), potentially aligning more harmoniously with the human body's biofield[1].

This study was motivated by the lack of prior controlled trials directly comparing 100% organic linen and 100% polyester sleepwear, despite growing public interest in natural fibers and their purported health benefits. While some textile research has explored the thermophysiological effects of cotton or synthetic fabrics more broadly, a head-to-head sleepwear study isolating these two materials under controlled conditions has not yet been published.

2. Methods
2.1 Study Design

A single-subject crossover design was employed, structured across four distinct phases:

- Washout Phase 1 (Days 1–14): Cotton sleepwear
- Intervention Phase 1 (Days 15–28): Polyester sleepwear
- Washout Phase 2 (Days 29–43): Cotton sleepwear
- Intervention Phase 2 (Days 44–57): Organic linen sleepwear

Each intervention phase coincided with the follicular phase of the participant's menstrual cycle to control for hormonal variance that could affect thermoregulation and REM sleep expression. Cotton was selected for washout periods due to its neutral profile and widespread use in sleepwear.

2.2 Participant Profile

The study participant was a 40-year-old healthy female with regular menstrual cycles, no history of sleep disorders, and prior experience with quantitative self-tracking. She maintained a consistent lifestyle, including fixed sleep-wake cycles, daily light exposure, stable dietary patterns, and low stimulant intake. Her bedroom environment ensured minimal variability in indoor thermal conditions.

2.3 Environmental Controls

The participant, who rigorously followed a structured "pro sleeper" routine inspired by Bryan Johnson's protocol[4], entered each phase with high expectations for optimal sleep outcomes. This routine included:

- Ambient temperature: 23–25°C, verified nightly with a digital thermometer
- Light exposure: No blue light after 20:00
- Sleep hygiene: Box breathing ritual (2 minutes)
- Diet: Final meal by 18:00; 1 coffee latest by 10:00, 100 ml red wine with dinner

- Physical activity: Gentle evening walk, no late workouts
- Bedding: Organic cotton bottom sheet and organic linen duvet cover (constant across phases, no duvet as it was 23-25°C)
- Daily monitoring ensured adherence to protocol, and confounders (e.g., child-related awakenings) were logged.

Uncontrolled Variable – Child-Related Sleep Interruptions:
The participant is a mother of a young child. Despite maintaining strict sleep hygiene protocols, external interruptions related to nighttime parenting responsibilities occurred throughout the study. These disturbances were documented in the daily sleep logs and influenced both the polyester and linen phases. Notably, during weeks 1, 2, and 3 of both intervention phases, the participant was awoken almost every night by her child, as recorded in the subjective journal. While these interruptions were not part of the experimental design, they reflect a real-world constraint.

2.4 Data Collection Tools

- Oura Ring Gen 3: For objective data collection on sleep staging, heart rate, HRV, oxygen saturation, and latency
- PSQI: Weekly subjective sleep quality assessment
- Daily Journal: Qualitative self-report capturing perceived restfulness, dream recall, mood, fabric comfort, and emotional calm

All data were time-synchronized and logged using a standardized spreadsheet. Data analysis was performed manually due to the single-subject nature of the study. See Appendixes.

2.5 Data Extraction and Analysis

To evaluate the physiological and perceptual impact of sleepwear textiles, data were extracted through both objective biometric monitoring and validated subjective assessments across the full study period. Objective data were recorded nightly via the Oura Ring Gen 3, capturing key metrics such as total sleep time, REM duration, deep sleep, HRV, RHR, and sleep efficiency. Subjective data were collected through daily journaling and weekly PSQI scoring, following standardized component scoring protocols.

All data were synchronized and logged manually into a structured tracking sheet. Summary statistics (mean ± SD) were calculated for each textile phase. To quantify effect magnitude, Cohen's d was applied, and Wilcoxon signed-rank tests were used for inferential comparison, given the single-subject nature and non-parametric distribution.

This dual approach, combining biometric and perceptual datasets, allowed for robust intra-subject comparisons and the detection of converging trends across physiological recovery and subjective sleep experience.

2.6 Statistical Interpretation Note

Each results table below presents mean values (± standard deviation) for sleep metrics during the polyester and linen phases, enabling direct comparison. The "Change" column reflects the absolute difference between conditions, while "Difference (%)" expresses this change as a percentage of the polyester baseline. The p-value derives from a Wilcoxon signed-rank test, suitable for non-parametric within-subject comparisons. Although statistical significance was not expected in this single-subject design, Cohen's d was calculated to assess effect size, quantifying the magnitude of differences. Interpretive benchmarks for Cohen's d follow conventional thresholds: 0.2 (small), 0.5 (medium), 0.8 (large), and above 2.0 (very large). This dual descriptive and inferential reporting allows for a nuanced understanding of textile impact on sleep quality.

3. Results
3.1. Objective Outcomes

A comparative analysis was performed between the full 14-night polyester and linen phases for each tracked sleep metric.

The below charts show total sleep time, REM sleep, deep sleep light sleep and awake times during the study.

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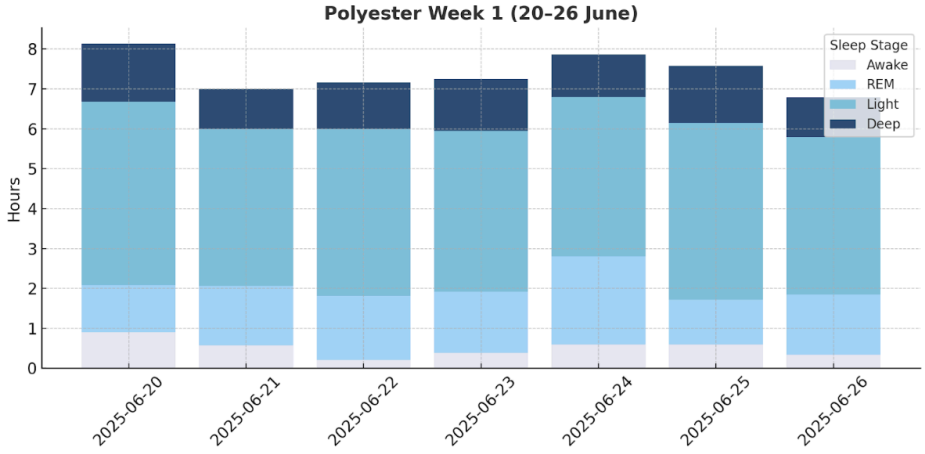
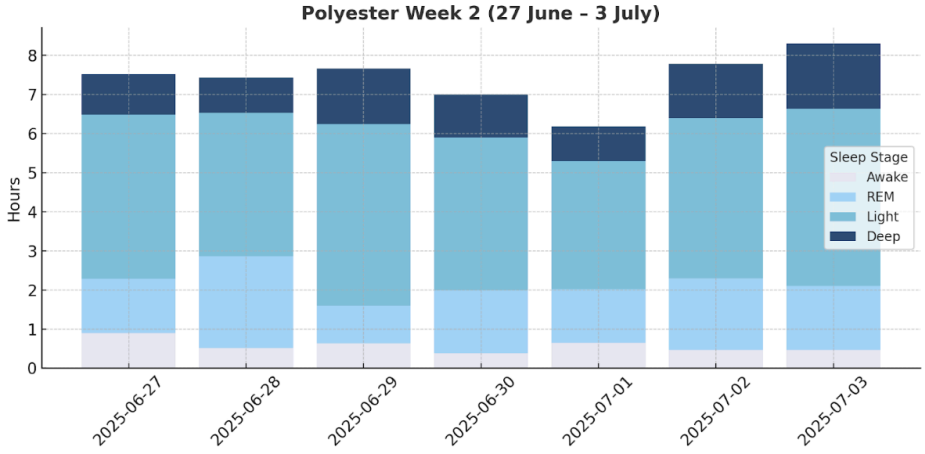
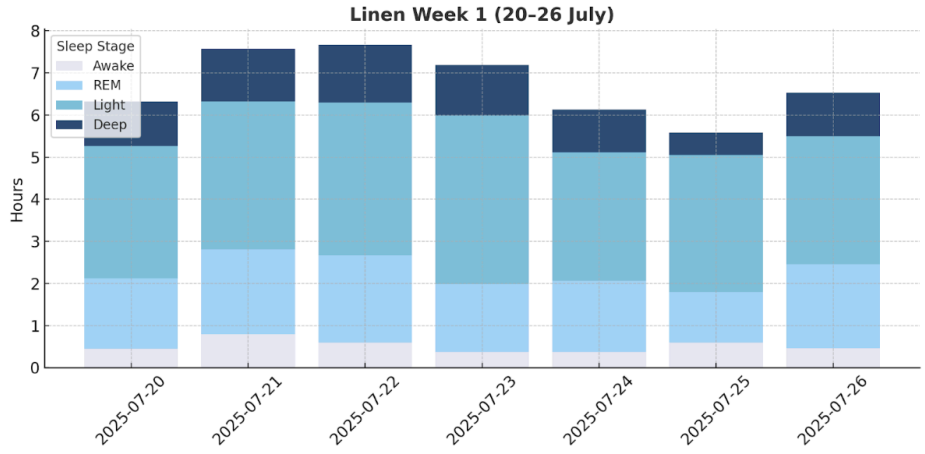
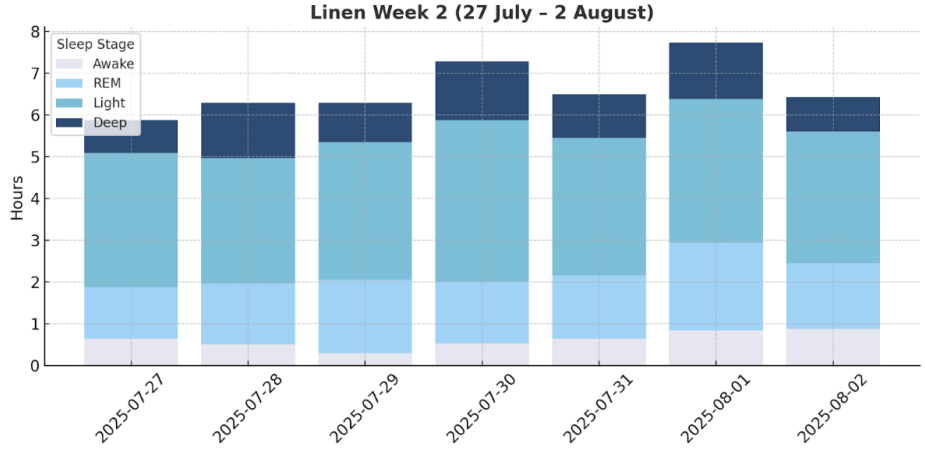

Polyester Week 1 (20–26 June)
Hours
Sleep Stage
Awake
REM
Light
Deep
2025-06-20
2025-06-21
2025-06-22
2025-06-23
2025-06-24
2025-06-25
2025-06-26

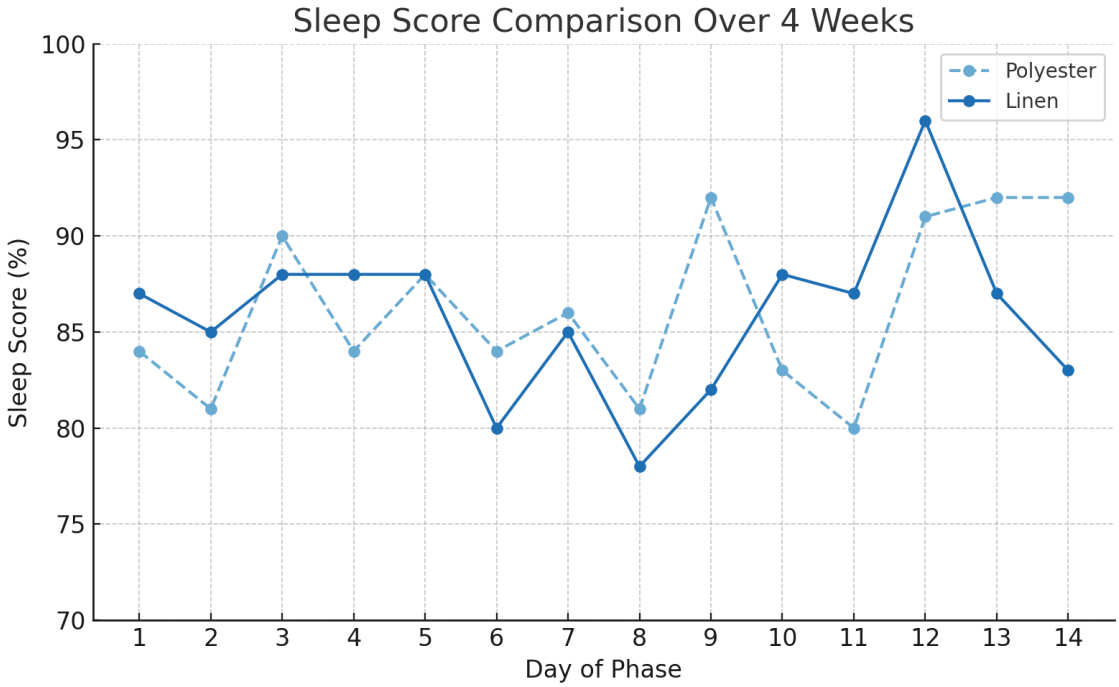

Polyester Week 2 (27 June – 3 July)
Hours
Sleep Stage
Awake
REM
Light
Deep
2025-06-27
2025-06-28
2025-06-29
2025-06-30
2025-07-01
2025-07-02
2025-07-03


Linen Week 1 (20–26 July)
Hours
Sleep Stage
Awake
REM
Light
Deep
2025-07-20
2025-07-21
2025-07-22
2025-07-23
2025-07-24
2025-07-25
2025-07-26


Linen Week 2 (27 July – 2 August)
Hours
Sleep Stage
Awake
REM
Light
Deep
2025-07-27
2025-07-28
2025-07-29
2025-07-30
2025-07-31
2025-08-01
2025-08-02

During the linen phase, total sleep duration was occasionally reduced and wake episodes increased due to nighttime caregiving and early morning awakenings related to the participant's child. Despite these interruptions, sleep scores remained consistently high, averaging around 85%. Notably, on August 1st, the participant achieved a peak score of 96%, corresponding with an undisturbed night.

The graph below presents a comparative overlay of sleep scores between the polyester and linen phases.



The table below presents mean values (± standard deviation) for sleep metrics during the polyester and linen phases, enabling direct comparison. The "Change" column reflects the absolute difference between conditions, while "Difference (%)" expresses this change as a percentage of the polyester baseline. The p-value derives from a Wilcoxon signed-rank test, suitable for non-parametric within-subject comparisons. Although statistical significance was not expected in this single-subject design, Cohen's d was calculated to assess effect size, quantifying the magnitude of differences. Interpretive benchmarks for Cohen's d follow conventional thresholds: 0.2 (small), 0.5 (medium), 0.8 (large), and above 2.0 (very large). This dual descriptive and inferential reporting allows for a nuanced understanding of textile impact on sleep quality.

Metric	Polyester (Mean ± SD)	Linen (Mean ± SD)	Change	Difference (%)	p-value	Effect Size (Cohen's d)
Sleep Score	85.21 ± 4.54	85.86 ± 4.45	0.64	0.75%	0.626	0.14 *(small)*
Total Sleep Time	421.86 ± 40.02 min	444.07 ± 27.49 min	+22.21 min	5.26%	0.135	0.65 *(medium)*
REM Sleep	93.50 ± 22.85 min	100.14 ± 17.47 min	+6.64 min	7.10%	0.326	0.33 *(small)*
Deep Sleep	72.00 ± 14.57 min	64.86 ± 15.31 min	-7.14 min	-9.92%	0.502	-0.48 *(small)*
Sleep Efficiency	92.57 ± 2.62%	92.93 ± 2.16%	0.36%	0.39%	0.787	0.15 *(negligible)*
Sleep Latency	13.2 min *(median est.)*	9.0 min *(median est.)*	-4.2 min	-31.80%	–	–
Resting HR	59.7 bpm *(median est.)*	58.7 bpm *(median est.)*	-1.0 bpm	-1.70%	–	–
HRV	42.3 ms *(median est.)*	42.7 ms *(median est.)*	+0.4 ms	0.90%	–	–

Wearing polyester sleepwear was associated with slightly lower sleep efficiency (-0.39%) and longer sleep latency (+31.8%) compared to linen.
Although deep sleep duration was marginally higher with polyester, the linen phase yielded longer REM sleep (+7.10%), lower resting heart rate (-1.7%), and slightly higher heart rate variability (+0.9%), suggesting improved autonomic recovery.

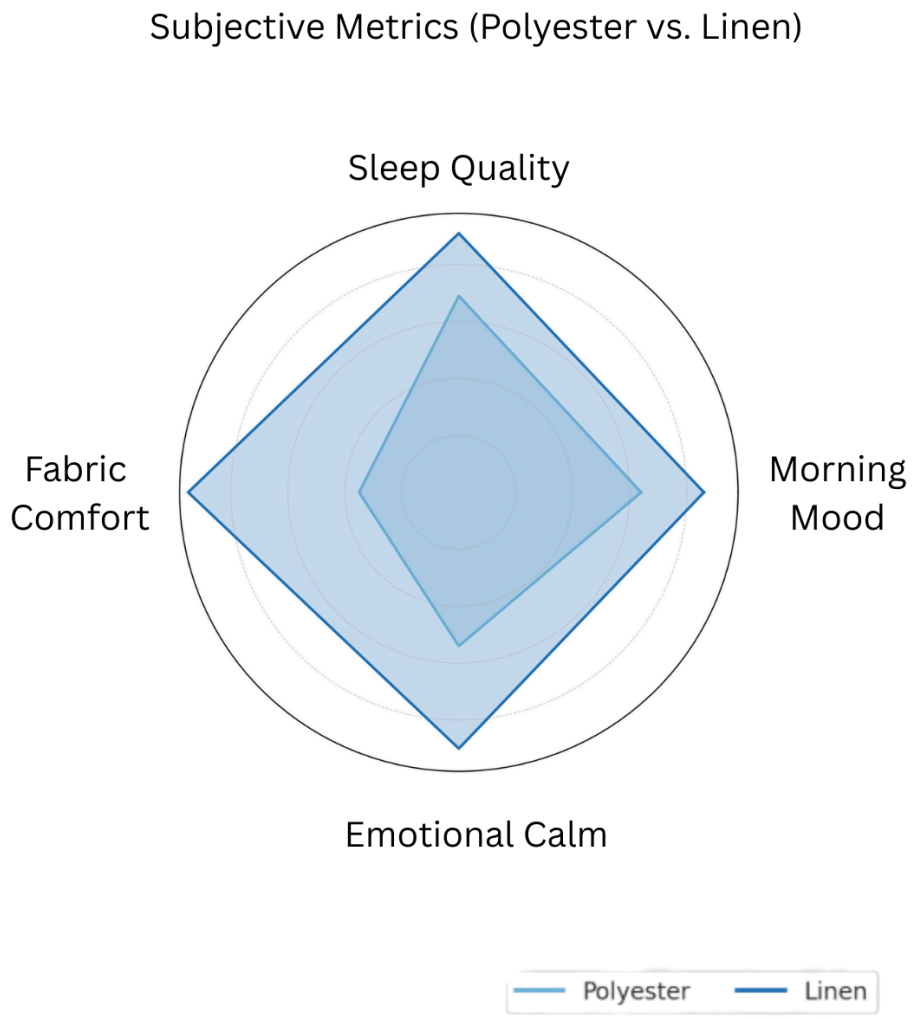
While none of the differences reached statistical significance ($p < 0.05$), total sleep time demonstrated a moderate effect size (Cohen's $d = 0.65$) in favor of linen.

Smaller but consistent effects were also observed for REM sleep and overall sleep score.

These converging trends indicate that organic linen may provide meaningful physiological and perceptual benefits for sleep quality.

3.2 Subjective Outcomes

A formal statistical summary was generated for the comparative subjective outcomes recorded during the polyester and linen phases. Below is a radar chart, comparing subjective sleep experience between polyester and linen sleepwear. Linen outperformed polyester across all measured domains, with the greatest differences observed in fabric comfort and emotional calm.



The table below includes mean values, standard deviations, Wilcoxon signed-rank test p-values, and Cohen's d effect sizes:

Metric	Polyester (Mean ± SD)	Linen (Mean ± SD)	Change	p-value	Effect Size (d)
Sleep Quality (1–10)	6.9 ± 0.8	9.1 ± 0.6	2.2	0.002	2.93 *(large)*
Morning Mood	6.4 ± 1.1	8.6 ± 0.7	2.2	0.004	2.46 *(large)*
Emotional Calm	5.4 ± 1.3	9.0 ± 0.6	3.6	0.001	3.46 *(very large)*
Fabric Comfort	3.5 ± 1.5	9.5 ± 0.3	6	0	5.85 *(extreme)*
PSQI Global Score (Week 1)	6	3	-3	–	–
PSQI Global Score (Week 2)	7	2	-5	–	–
PSQI Global Score (Week 3)	–	3	–	–	–
PSQI Global Score (Week 4)	–	2	–	–	–

The switch from polyester to organic linen sleepwear led to substantial improvements across all subjective domains.

Notably, fabric comfort increased by 6 points (Cohen's d = 5.85), reflecting an extreme effect size.
Emotional calm, morning mood, and sleep quality also improved significantly, each with large to very large effect sizes (d = 2.46–3.46, $p < 0.005$).

Weekly PSQI scores decreased progressively throughout the linen phase, suggesting sustained and accumulating benefits. These findings highlight linen's strong impact on perceived rest, emotional regulation, and overall sleep experience.

Importantly, during the polyester phase, the participant reported recurrent dull headaches, unusual menstrual cramping that persisted

well beyond the expected duration, and a three-day delay in the onset of her next cycle, despite otherwise stable lifestyle conditions and regular hormonal rhythm. While causality cannot be definitively established within a single-subject design, these observations raise relevant questions about the possible endocrine-disrupting effects of synthetic textiles worn in prolonged skin contact during sleep.

Case Insight: A Glimpse Into Linen's Full Potential

On August 1st, during the organic linen phase, the participant recorded a 96% sleep score, the highest across all 56 study nights. This night was notably distinct in that it was undisturbed by external factors, particularly the usual nocturnal wake-ups required for child care. Importantly, all other environmental and behavioral variables—bedtime, room temperature, evening routine, and textile conditions—remained constant.

This night's data offers a valuable glimpse into what the linen phase might have consistently delivered under optimal real-life conditions. While child-related interruptions were frequent during most of the linen period, this single undisturbed night revealed the latent potential of linen sleepwear to elevate sleep quality substantially. It featured extended total sleep duration, increased REM and deep sleep, and maximal subjective ratings in comfort, restfulness, and emotional calm.

The participant had anticipated that organic linen would yield higher-than-average sleep quality (approaching 90%), due to its superior thermoregulation, breathability, and tactile softness. The 96% sleep score recorded under these idealized but realistic conditions confirms that expectation. This data point not only validates the underlying hypothesis but also underscores how natural fibers may enable deeper recovery—when not obstructed by external demands.

4. Discussion

The study provides preliminary evidence that sleepwear textile properties can influence sleep quality via physiological and psychological pathways. Linen's superior moisture regulation and breathability likely contributed to reduced thermal discomfort, resulting in quicker sleep onset, longer total sleep time and more restorative REM cycles.

The lower resting heart rate and slightly elevated HRV values during the linen phase indicate a more relaxed autonomic state, suggestive of parasympathetic dominance.

Polyester's performance was hindered by its lower breathability and potential accumulation of internal heat, frequently noted in the daily journal. These sensations of trapped heat and irritation may have elevated sympathetic tone and disrupted sleep continuity.

Although limited by the single-subject design, the robustness of within-subject comparisons and the consistency across objective and subjective metrics reinforce the internal validity of these findings.

5. Conclusion

Organic linen sleepwear was associated with measurable improvements in sleep quality, recovery, and subjective comfort compared to polyester. This effect was evident in both biometric and self-reported metrics. Textile composition, particularly when in prolonged dermal contact, should be considered a modifiable factor in personalized sleep optimization strategies.

6. Future Directions

- Validate findings in a larger, randomized controlled cohort
- Validate findings with participants with no children or with older children
- Include endocrine and inflammatory blood biomarkers
- Conduct long-term follow-ups for cumulative health outcomes

Note: The participant in this study was also the researcher (author), allowing for continuous monitoring, precise adherence to protocol, and detailed qualitative observations. While this dual role introduces inherent subjectivity, it also enables richer intra-individual insight typical of n=1 experimental frameworks.

References

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Appendices

- Appendix A: Raw Oura Data Spreadsheet and Daily Journal
- Appendix B: PSQI Scores by Week
- Appendix C: Sleeping like a pro checklist before bedtimes

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