

Development and Psychometric Validation of the Human Sustainability Index (HSI-CV1): A Multiphase Mixed-Methods Study Protocol With Physiological Anchoring and Longitudinal Predictive Validity

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Abstract

Background. Contemporary approaches to mental health and human development increasingly recognize that sustainable functioning depends not only on the absence of psychological illness but also on resilience, supportive environments, social connectedness, access to preventive resources, and the regulatory capacity of the body. However, existing instruments frequently assess these dimensions separately, and almost none pairs self-report with physiological measurement. A multidimensional instrument capable of examining the sustainability of human functioning across psychological, relational, organizational, preventive, and physiological domains may provide a useful framework for research and intervention. The present study proposes the development and psychometric validation of the Human Sustainability Index (HSI-CV1), a multidimensional self-report instrument designed to assess conditions associated with sustainable psychological and social functioning across the life course.

Objective. The primary objective is to develop and evaluate the reliability, validity, factor structure, physiological convergence, responsiveness, and longitudinal predictive utility of the HSI-CV1.

Methods. A multiphase mixed-methods design will be used. Phase 1 will involve construct definition and item generation through literature review and theoretical synthesis. Phase 2 will involve expert evaluation of item relevance, clarity, and content validity. Phase 3 will use cognitive interviews to evaluate comprehension and response processes. Phase 4 will involve pilot administration and exploratory factor analysis (EFA). Phase 5 will involve confirmatory factor analysis (CFA), reliability assessment, convergent and discriminant validity testing, and measurement-invariance analysis. A physiological subsample will wear a validated consumer device for seven days to test convergence between HSI scores and vagally mediated heart rate variability (HRV), resting heart rate, and sleep. A brief regulatory intervention sub-study will test responsiveness. A longitudinal subsample will subsequently be assessed to examine test-retest reliability and predictive validity. The anticipated primary sample will comprise approximately 1,200–1,500 adults recruited across multiple occupational and social contexts, including a tertiary hospital in northern India.

Expected contribution. The HSI-CV1 is intended to provide a multidimensional framework for evaluating human sustainability and identifying psychological, relational, organizational, preventive, and physiological factors associated with sustainable functioning. The study will establish the preliminary psychometric foundation required for subsequent epidemiological, clinical, organizational, and longitudinal research.

Keywords: human sustainability, psychological well-being, resilience, burnout, social connectedness, preventive health, heart rate variability, nature exposure, psychometrics, scale development

Introduction

Background

Mental health research has increasingly moved beyond a narrow disease-oriented framework toward models that incorporate positive functioning, resilience, social relationships, environmental conditions, and preventive health. The distinction between mental illness and positive psychological functioning has been particularly influential in contemporary models of mental health. Keyes (2002), for example, conceptualized mental health as a continuum extending from languishing to flourishing rather than simply as the absence of psychiatric disorder. Similarly, psychological well-being research has emphasized dimensions such as autonomy, positive relationships, environmental mastery, purpose in life, personal growth, and self-acceptance (Ryff, 1989, 2014).

Resilience research has further demonstrated that psychological functioning is dynamic and influenced by an individual's capacity to adapt to adversity (Masten, 2001). At the same time, social relationships are increasingly recognized as fundamental determinants of health and longevity (Holt-Lunstad, 2018), while occupational burnout and chronic workplace stress have become major concerns for individual and organizational functioning (World Health Organization, 2019). A parallel literature in psychophysiology has established that the capacity for emotion regulation, flexible attention, and social engagement is supported by a prefrontal–vagal circuit whose output can be read peripherally as HRV (Thayer & Lane, 2000; Thayer et al., 2012), that HRV predicts all-cause mortality (Jarczok et al., 2022), and that it is reliably raised by slow breathing (Laborde et al., 2022) and by contact with natural environments (Robat et al., 2026).

These bodies of research suggest that sustainable human functioning is multidimensional. However, these dimensions are frequently measured independently, and self-report is rarely anchored to physiology. A person may demonstrate high psychological resilience but experience severe workplace burnout. Another may have strong social support but poor access to preventive healthcare. Another may

report good psychological well-being while functioning within an organizational environment characterized by chronic instability, or while showing the suppressed HRV and fragmented sleep of a nervous system held in what the preceding papers in this programme call the *Red Mind*. Consequently, there is a need for an integrative framework capable of examining multiple interacting conditions that support or undermine sustainable human functioning. The present study introduces the Human Sustainability Index (HSI-CV1).

Conceptual Definition of Human Sustainability

For the purposes of this study, human sustainability is defined as: *the capacity of individuals and the environments in which they live and work to support sustained psychological functioning, adaptive resilience, meaningful social connection, healthy participation, physiological recovery, and access to preventive resources across the life course*. The construct differs from psychological well-being because it includes both individual capacities and contextual conditions. It also differs from conventional health measures because it explicitly incorporates psychological, relational, organizational, preventive, and physiological dimensions. Human sustainability is therefore conceptualized as an interaction between: Person $\times$ Body $\times$ Relationships $\times$ Environment $\times$ Resources $\times$ Time.

The Human Sustainability Index

The initial HSI-CV1 framework contains six domains.

Domain 1: Psychological Well-Being and Resilience assesses emotional functioning, psychological stability, coping capacity, resilience, recovery from adversity, and perceived ability to manage life demands. The domain draws upon established literature concerning psychological well-being and resilience (Keyes, 2002; Masten, 2001; Ryff, 1989).

Domain 2: Burnout and Emotional Exhaustion assesses emotional exhaustion, chronic psychological depletion, inability to recover from demands, detachment, and sustained overload. Burnout is treated as a sustainability-related risk condition rather than simply as an occupational outcome. The Maslach Burnout Inventory and related burnout research provide an established theoretical foundation for this domain (Maslach & Leiter, 2016).

Domain 3: Organizational and Leadership Support evaluates the degree to which the individual's work or organizational environment supports sustainable functioning, including psychological safety, supportive leadership, autonomy, recognition, workload sustainability, fairness, and organizational belonging. This domain recognizes that individual resilience cannot compensate indefinitely for chronically harmful environments.

Domain 4: Community and Social Connectedness assesses belonging, social support, meaningful relationships, community participation, loneliness, and interpersonal connectedness. The domain is supported by extensive evidence linking social relationships with physical and psychological health (Holt-Lunstad, 2018).

Domain 5: Access to Preventive Resources and Help-Seeking assesses awareness of available resources, access to mental and physical healthcare, preventive behavior, willingness to seek help, perceived accessibility of support, and barriers to care. This domain is intentionally included because sustainable human functioning depends not only on internal psychological resources but also on the availability and accessibility of external support.

Domain 6: Physiological Regulation and Restorative Environment assesses the regulatory state of the body and access to the conditions that restore it: perceived recovery capacity, sleep quality, subjective vitality, frequency of contact with natural and blue (aquatic) environments, regular slow-breathing or contemplative practice, protection of the first hour after waking and the last hour before sleep from stimulation, and nature connectedness. This domain is new to the framework and is treated as exploratory: the protocol is designed to determine whether it forms a distinct factor, loads on existing domains, or splits into regulatory and environmental components. It is the only domain for which an objective physiological criterion (HRV) is available, and it therefore carries the study's physiological validation arm.

Table 1. Proposed HSI-CV1 Domains

Domain	Core construct
1. Psychological Well-Being & Resilience	Internal psychological resources and adaptive capacity
2. Burnout & Emotional Exhaustion	Psychological depletion and chronic overload
3. Organizational & Leadership Support	Environmental and workplace sustainability
4. Community & Social Connectedness	Belonging, relationships, and social participation
5. Preventive Resources & Help-Seeking	Access, awareness, prevention, and willingness to seek support
6. Physiological Regulation & Restorative Environment (exploratory)	Autonomic recovery capacity (Red Mind $\leftrightarrow$ Blue Mind) and access to nature, water, breath, and protected sleep transitions

Study Objectives

The study will pursue eight primary objectives: (1) to develop an initial item pool representing the six conceptual domains of the HSI-CV1; (2) to establish content validity through expert review; (3) to evaluate item comprehension and response processes through cognitive interviewing; (4) to determine the preliminary factor structure using exploratory factor analysis; (5) to confirm the factor structure and evaluate reliability and construct validity; (6) to test convergence between HSI scores and objective physiological indices in a wearable subsample; (7) to evaluate responsiveness to a brief regulatory intervention; and (8) to examine the longitudinal stability and predictive validity of HSI scores.

Research Questions

The study will address the following questions: Does the proposed six-domain structure adequately represent human sustainability, and does Domain 6 survive as a distinct factor? Do HSI items demonstrate acceptable content validity? Are the domains internally consistent? Does the proposed factor structure demonstrate adequate model fit? Does the HSI demonstrate convergent and discriminant validity, including convergence with HRV, sleep, and resting heart rate? Is the HSI measurement structure stable across relevant demographic, occupational, and linguistic groups? Is the HSI responsive to a short intervention known to shift autonomic state? Do baseline HSI scores predict subsequent psychological, functional, and physiological outcomes?

Hypotheses

- H1.* The HSI-CV1 will demonstrate a multidimensional factor structure corresponding to the six proposed domains, with Domain 6 either forming a distinct factor or a coherent pair of regulatory and environmental sub-factors.
- H2.* HSI domains will demonstrate acceptable internal consistency.
- H3.* HSI scores will demonstrate positive associations with established measures of psychological well-being, resilience, social connectedness, perceived support, nature relatedness, recovery experience, and subjective vitality.
- H4.* HSI scores will demonstrate negative associations with burnout, emotional exhaustion, and poor sleep quality.
- H5.* HSI scores will demonstrate evidence of discriminant validity from conceptually distinct constructs.
- H6.* Total HSI and Domain 6 scores will correlate positively with vagally mediated HRV (nocturnal RMSSD) and negatively with resting heart rate in the wearable subsample, after adjustment for age, sex, body-mass index, physical activity, and medication.
- H7.* HSI-CV1 will be responsive: a four-week regulatory intervention (slow breathing, nature contact, and protected first and last hours) will produce a greater increase in Domain 6 and total HSI scores, and in nocturnal RMSSD, than a wait-list condition.
- H8.* Higher baseline HSI scores will predict better psychological, functional, and physiological outcomes at follow-up.

Methods

Study Design

A multiphase mixed-methods design will be used. The study will proceed through five sequential phases, with two embedded sub-studies in Phase 5: Phase 1 — construct and item development; Phase 2 — expert content validation; Phase 3 — cognitive interviewing; Phase 4 — pilot testing and exploratory factor analysis; Phase 5 — confirmatory validation with a physiological subsample and a responsiveness sub-study, followed by longitudinal assessment.

Setting and Recruitment

Participants will be recruited across multiple occupational and social contexts, including corporate, educational, healthcare, caregiving, and community settings. One recruitment site will be a tertiary multispecialty hospital in Prayagraj, Uttar Pradesh, which provides access to three populations of particular relevance to the construct: healthcare workers, among whom burnout is consistently documented; family caregivers of surgical and oncology patients; and cancer survivors, for whom disruption is dated and both physiological and psychological trajectories can be followed from a common starting point. The instrument will be developed in English and forward- and back-translated into Hindi following standard procedures, permitting measurement invariance to be tested across language as well as demographic groups.

Phase 1: Item Development

An initial item pool of approximately 60–80 items will be generated, with approximately 10–15 candidate items initially representing each domain. Items will be concise, written in accessible language, focused on one construct at a time, suitable for adult respondents, and free of unnecessary clinical terminology. Domain 6 items will address behaviour and experience rather than physiology directly (for example, “Most weeks I spend time in a natural setting,” “I wake feeling recovered,” “The first hour of my day is free of screens and work”), so that the domain can be scored in populations without wearables.

Both positively and negatively worded items will initially be considered, although excessive reverse wording will be avoided because it can introduce method effects. The preliminary response format will use a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). A small number of frequency-based items may use equivalent five-point anchors where appropriate.

Phase 2: Expert Content Validation

A multidisciplinary expert panel of approximately 10–15 experts will review the initial item pool. Experts may include professionals from clinical psychology, psychiatry, public health, occupational health, organizational psychology, behavioral medicine, clinical medicine and surgery, psychophysiology, environmental psychology, and preventive healthcare. Each item will be evaluated for relevance, clarity, representativeness, and conceptual fit. The Content Validity Index (CVI) will be calculated at both item and scale levels. Items demonstrating poor relevance or clarity will be revised or removed, and qualitative comments will be incorporated into item refinement.

Phase 3: Cognitive Interviewing

Approximately 20–30 adults representing different demographic, occupational, and linguistic backgrounds will participate in cognitive interviews. Participants will be asked to describe how they interpret each item, what the item means to them, how they selected their response, and whether any wording is confusing or ambiguous. Think-aloud and verbal-probing techniques will be used where appropriate. Items producing consistent misunderstanding, including cross-linguistic drift between English and Hindi versions, will be revised. This phase will ensure that psychometric performance is not pursued at the expense of conceptual clarity.

Phase 4: Pilot Study and Exploratory Factor Analysis

A pilot sample of approximately 400–500 participants will be recruited from multiple sectors and occupational contexts. Descriptive statistics will initially be examined for missingness, skewness, floor and ceiling effects, and response distributions. Items with substantial redundancy, poor variability, excessive missingness, or weak relationships with their intended domain will be reviewed.

EFA will be conducted to examine the underlying structure. Factor retention will be informed by parallel analysis, scree plot, eigenvalues, and theoretical interpretability. Oblique rotation will be used because the HSI domains are expected to be correlated. Items demonstrating weak factor loadings or substantial cross-loadings will be considered for removal. The aim will be to retain a theoretically coherent and practically usable instrument rather than maximizing the number of items.

Phase 5: Confirmatory Validation

A separate sample of approximately 700–1,000 participants will be used for CFA. This separation between EFA and CFA samples will reduce the risk of capitalizing on chance. The hypothesized model will initially contain six correlated first-order factors. A five-factor

model (Domain 6 absorbed), a seven-factor model (Domain 6 split into regulatory and environmental components), and a bifactor model will be compared. A higher-order HSI factor may subsequently be tested if theoretically and statistically justified. Model fit will be evaluated using the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). Interpretation will follow contemporary recommendations rather than relying on rigid universal cutoffs (Hu & Bentler, 1999; Kline, 2016).

Reliability

Internal consistency will be evaluated using Cronbach's alpha and McDonald's omega. Omega will be emphasized because it can provide a more appropriate estimate under conditions where tau-equivalence is not met. Test–retest reliability will be evaluated in a subsample after approximately 2–4 weeks. Intraclass correlation coefficients will be considered alongside correlation coefficients.

Construct Validity

Convergent validity. HSI domains are expected to correlate with conceptually related measures: psychological well-being, resilience, perceived social support, and purpose in life for Domains 1–5; and, for Domain 6, the NR-6 nature-relatedness scale (Nisbet & Zelenski, 2013), the Recovery Experience Questionnaire (Sonnentag & Fritz, 2007), the Subjective Vitality Scale (Ryan & Frederick, 1997), the Pittsburgh Sleep Quality Index (Buysse et al., 1989), and the Perceived Restorativeness Scale (Hartig et al., 1997).

Discriminant validity. The HSI should remain distinguishable from constructs that are theoretically related but conceptually different. Analyses will examine whether the HSI demonstrates adequate separation from general negative affect, demographic characteristics, and unrelated personality dimensions.

Criterion and known-groups validity. HSI scores will be compared across theoretically distinct groups: high versus low perceived workplace support; high versus low burnout; strong versus weak social connectedness; clinical staff in high-acuity services versus administrative staff; night-shift versus day workers; and adults reporting regular nature, water, or breathing practice versus none. Individuals exposed to more supportive and restorative conditions are expected to show higher HSI scores, while individuals experiencing substantial psychological depletion are expected to show lower scores.

Physiological Validation Arm

A subsample of approximately 150–200 participants drawn from the CFA sample will wear a consumer wearable device for seven consecutive days. Devices will be selected from those with published validation against electrocardiography and polysomnography for heart rate, HRV, and sleep (Miller et al., 2022). The primary physiological index will be nocturnal root mean square of successive differences (RMSSD), the time-domain measure most closely reflecting vagal modulation and most robust to consumer-device sampling (Shaffer & Ginsberg, 2017); secondary indices will be resting heart rate, sleep duration, sleep regularity, and respiratory rate. Seven-night averages will be used to reduce day-to-day variance. Reporting will follow published recommendations for HRV in psychophysiological research (Laborde et al., 2017). Analyses will test whether total HSI and Domain 6 scores are associated with RMSSD and resting heart rate after adjustment for age, sex, body-mass index, self-reported physical activity, alcohol, and cardioactive medication, and whether Domain 6 explains variance in RMSSD beyond Domains 1–5. A subset will additionally provide a five-minute seated HRV recording under standardized conditions to cross-check device-derived values. This arm provides the framework's first objective anchor: if the questionnaire captures what it claims to capture, people who report living more of their day in the Blue Mind should show it in their heart.

Responsiveness Sub-Study

Because a sustainability index must be sensitive to change to be useful for intervention research, responsiveness will be tested directly, consistent with COSMIN criteria (Mokkink et al., 2010). Approximately 80–100 participants from the physiological subsample will be randomized to a four-week regulatory protocol or a wait-list. The protocol combines three components each supported by independent evidence: ten minutes daily of paced breathing at approximately six breaths per minute (Laborde et al., 2022); a target of at least 120 minutes per week in a natural or blue-space setting (White et al., 2019); and protection of the first hour after waking and the last hour before sleep from screens and work, given the circadian sensitivity of these windows (Chang et al., 2015; Stalder et al., 2016). Adherence will be logged. HSI-CV1, the convergent measures, and seven-day wearable indices will be collected before and after the intervention. The primary responsiveness outcome is the between-group difference in change in Domain 6 and total HSI; the secondary outcome is change in nocturnal RMSSD. Effect sizes with confidence intervals will be reported. The sub-study is designed to test the instrument's sensitivity, not to establish the intervention's efficacy, for which it is underpowered.

Measurement Invariance

Measurement invariance will be examined across relevant groups where sample size permits: gender, age group, occupational sector, and language of administration (English versus Hindi). Sequential testing will examine configural, metric, and scalar invariance. Where appropriate, changes in fit indices will be interpreted rather than relying exclusively on chi-square difference tests.

Longitudinal Validation

A longitudinal subsample will be followed for approximately 6–12 months, retaining the wearable subsample where feasible. The primary purpose will be to determine whether baseline HSI scores predict subsequent outcomes, including psychological well-being, burnout, perceived stress, social connectedness, help-seeking, functional well-being, sickness absence, and, in the wearable subsample, change in RMSSD and resting heart rate. Longitudinal analyses may use regression or mixed-effects models depending on the final structure of the data, and an exploratory mediation model will test whether Domain 6 (physiological regulation) mediates the relationship between environmental conditions (Domains 3–5) and psychological capacity (Domains 1–2). The primary hypothesis is: higher baseline human sustainability will predict better psychological, functional, and physiological outcomes over time.

Sample Size

The overall target sample is approximately 1,200–1,500 participants. This will permit pilot item analysis, EFA, independent CFA, subgroup analyses where feasible, the physiological and responsiveness sub-studies, and longitudinal follow-up. The final sample-size

decision will be refined according to the number of retained items, anticipated factor complexity, communalities, model parameters, and expected attrition. Rather than relying solely on a participants-per-item rule, the final sample size will be justified using contemporary recommendations for factor-analysis sample planning and model complexity. For the physiological arm, 150 participants provide over 80% power to detect a correlation of 0.25 between HSI and RMSSD at $\alpha = 0.05$.

Statistical Analysis Plan

Analyses will be conducted using established statistical software. The analysis sequence will be: (1) data cleaning and missing-data assessment; (2) descriptive item analysis; (3) content-validity analysis; (4) exploratory factor analysis; (5) confirmatory factor analysis and model comparison; (6) internal-consistency analysis; (7) test-retest reliability; (8) convergent and discriminant validity, including physiological convergence; (9) measurement invariance; (10) responsiveness analysis; and (11) longitudinal predictive and mediation analyses. Statistical significance will not be interpreted independently of effect sizes, confidence intervals, theoretical coherence, and model fit.

Scoring

The final scoring system will be determined following psychometric validation. For the initial instrument, item responses will be coded from 1 to 5; negatively keyed items will be reverse scored; domain scores will be calculated from retained items; and an overall HSI score may be calculated if evidence supports a general factor. Higher scores will indicate greater human sustainability. Where wearable data are available, a supplementary physiological profile (RMSSD, resting heart rate, sleep regularity) will be reported alongside, not folded into, the self-report score until the relationship between the two is empirically established. The final instrument will include a formal scoring manual specifying retained items, reverse-scored items, domain calculations, treatment of missing responses, and interpretation guidelines. Importantly, clinical cutoffs will not be created unless empirically justified. The HSI-CV1 will initially be considered a dimensional research instrument rather than a diagnostic test.

Ethical Considerations

The study will obtain approval from an appropriate institutional ethics committee at each site before participant recruitment. All participants will provide informed consent. Participation will be voluntary, and participants will be informed that they may withdraw at any time without consequence. Because some HSI items may address emotional exhaustion, psychological distress, loneliness, or help-seeking, participants will be provided with appropriate information regarding available support resources where required. Wearable data will be collected under a separate consent, stored pseudonymously, and used only for the analyses specified; participants will be told that consumer devices are not medical instruments and that no clinical conclusions will be drawn from them. No individual-level diagnostic conclusions will be made from HSI scores. Participant confidentiality and data security will be maintained throughout the study.

Data Management and Transparency

The study protocol, final item set, statistical-analysis plan, and codebook should ideally be preregistered before confirmatory analyses. Where ethically and legally permissible, anonymized data and analysis code may subsequently be made available to support scientific reproducibility. Any deviations from the preregistered protocol will be transparently documented.

Expected Outcomes

The study is expected to produce: (1) a theoretically grounded HSI-CV1 item pool in English and Hindi; (2) evidence of content validity; (3) a stable multidimensional factor structure, with an empirical verdict on the status of Domain 6; (4) estimates of internal and temporal reliability; (5) evidence of convergent and discriminant validity, including the first physiological anchoring of a human-sustainability measure; (6) evidence of responsiveness; (7) preliminary measurement invariance evidence across demographic and linguistic groups; and (8) initial evidence of longitudinal predictive validity. The resulting instrument is intended to provide a concise multidimensional measure of conditions associated with sustainable human functioning.

Discussion

The Human Sustainability Index is proposed as an integrative framework rather than a replacement for established psychological or health measures. Its principal contribution is the integration of six domains that are often studied separately, and the pairing of self-report with an objective physiological criterion. The model recognizes that sustainable functioning cannot be understood exclusively through individual psychological characteristics. A person's capacity to remain psychologically healthy is influenced by internal resources, emotional workload, organizational conditions, relationships, access to preventive resources, and the regulatory state of the body.

This distinction is particularly important for intervention. If low HSI scores arise primarily from psychological vulnerability, psychological intervention may be appropriate. If low scores arise from organizational conditions, individual resilience training alone may be insufficient. If low scores arise from social isolation, community-level interventions may be necessary. If low scores reflect inadequate access to healthcare, structural interventions become relevant. If low scores are concentrated in Domain 6, the least expensive interventions in the framework, nature, water, breath, and protected sleep transitions, become first-line. The HSI therefore has the potential to function not merely as an assessment instrument but as a systems-level framework for identifying sustainability gaps.

Clinical Implications

The HSI may eventually support preventive psychological assessment by identifying vulnerabilities before they become severe clinical problems. Potential applications include preventive mental healthcare, employee well-being, university populations, healthcare professionals, caregiver populations, cancer survivorship and prehabilitation programmes, community mental health, and healthy-aging programs. However, clinical implementation should occur only after adequate validation and establishment of appropriate interpretive standards.

Organizational Implications

Organizations increasingly recognize that employee well-being cannot be reduced to individual coping skills. An employee experiencing chronic overload within an unsupportive organizational environment may not benefit sufficiently from resilience training alone. The HSI's organizational domain therefore creates the possibility of distinguishing individual sustainability from environmental sustainability, and Domain 6 allows an organization to see whether its people are recovering between demands or merely enduring them.

Public Health Implications

At the population level, the HSI may eventually provide a framework for examining psychological sustainability alongside conventional health indicators. Potential future applications include population surveys, workplace health surveillance, community well-being assessment, urban green- and blue-space planning, preventive mental-health planning, and healthy-aging initiatives. The instrument could potentially contribute to a broader understanding of human development in which health is considered not only in terms of disease burden but also in terms of sustainable functioning.

Limitations

Several limitations should be anticipated. First, the HSI is a newly proposed construct and may demonstrate conceptual overlap with existing measures. Second, self-report measures are vulnerable to response bias. Third, cross-sectional psychometric analyses cannot establish causality. Fourth, longitudinal attrition may affect predictive-validity analyses. Fifth, cultural and socioeconomic differences may influence how respondents understand psychological well-being, agency, support, help-seeking, and nature contact. Sixth, consumer wearables approximate rather than replicate laboratory HRV, and HRV is influenced by age, fitness, medication, and measurement conditions; the physiological arm is therefore a test of convergence, not a gold standard. Seventh, the responsiveness sub-study is powered to detect change in the instrument, not to evaluate the intervention. Finally, the six-domain model represents a theoretical starting point; empirical evidence may require domains to be modified, combined, or expanded. The purpose of psychometric validation is therefore not to confirm the framework regardless of findings, but to determine whether the proposed structure survives empirical testing.

Future Research

Following initial validation, future research should investigate population-level normative distributions; cross-cultural validity; clinical utility; organizational applications; adolescent and young-adult adaptations; older-adult applications; longitudinal change; intervention sensitivity across a wider range of regulatory practices, including cold-water immersion and grounding, for which current evidence is preliminary; associations with physical-health outcomes; and relationships between HSI scores and healthspan and longevity indicators, including biological-age estimates. Future studies may also investigate whether human sustainability, and specifically its physiological domain, functions as a mediator between environmental conditions and long-term health outcomes.

Conclusion

Human sustainability represents a shift from asking whether individuals are merely free from illness toward asking whether the conditions surrounding them, and the bodies they live in, support sustainable human functioning. The Human Sustainability Index operationalizes this proposition through six domains: Psychological Well-Being and Resilience; Burnout and Emotional Exhaustion; Organizational and Leadership Support; Community and Social Connectedness; Preventive Resources and Help-Seeking; and Physiological Regulation and Restorative Environment. The proposed multiphase study will establish whether these domains can be measured reliably and validly within a unified framework, whether the questionnaire is reflected in the physiology it claims to describe, and whether it moves when the conditions of life move. The ultimate objective is not to create another generic well-being scale. It is to develop an instrument capable of answering a broader question: are the psychological, relational, organizational, preventive, and physiological conditions surrounding a person sufficient to sustain human functioning over time? The HSI-CV1 therefore represents an initial empirical step toward operationalizing the broader concept of Human Sustainability and creating a measurable foundation for future research, prevention, and policy.

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