Scientific Research Publishing

Health, 2026, 18(6), 569-583
https://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

Association between Upper Thoracic Spine Findings and Cardiac-Related Functional Symptoms: A Pilot Observational Study

Philip Yang

California University-Silicon Valley (CUSV), Sunnyvale, USA
Email: philip@cusv.edu

How to cite this paper: Yang, P. (2026) Association between Upper Thoracic Spine Findings and Cardiac-Related Functional Symptoms: A Pilot Observational Study. *Health*, **18**, 569-583.
https://doi.org/10.4236/health.2026.186034

Received: April 19, 2026
Accepted: June 9, 2026
Published: June 12, 2026

Abstract

Background: Cardiovascular disease remains a leading cause of mortality worldwide. In parallel with established cardiovascular risk factors, there is continuing interest in whether neuromusculoskeletal and autonomic mechanisms may contribute to cardiac-related symptom perception or regulation. The upper thoracic spine is anatomically relevant to sympathetic pathways connected to the heart, but clinical evidence linking upper thoracic findings with cardiac-related symptoms remains limited. **Objective:** To explore whether palpation-based upper thoracic spine findings at T1-T5 are associated with cardiac-related functional symptoms in a pilot observational clinical sample. **Methods:** This pilot observational study included 100 patients assessed in a clinical teaching setting. T1-T5 irregularity was defined as any palpation-based upper thoracic finding at one or more segments from T1 to T5, including asymmetry, deviation, or reduced/restricted segmental mobility. Symptom status was defined as the presence or absence of cardiac-related symptoms at the time of assessment, including palpitations, chest discomfort or tightness, irregular heartbeat, shortness of breath, or suspected arrhythmia. Traditional Chinese medicine pulse assessment and conventional cardiac records, when available, were used descriptively. The primary analysis examined the association between T1-T5 irregularity and symptom status using the chi-square test. **Results:** Of 100 patients, 80 had cardiac-related symptoms and 20 did not. T1-T5 irregularity was identified in 80 patients and was absent in 20. Among patients with T1-T5 irregularity, 68/80 (85%) had symptoms, compared with 12/20 (60%) among those without such findings. Chi-square analysis showed a statistically significant association between T1-T5 irregularity and cardiac-related symptoms ($\chi Z = 6.67$, $p = 0.0098$), with a small-to-moderate effect size (Cramér's V = 0.26). Exploratory notes in the clinical records suggested that greater perceived spinal abnormality and greater symptom burden may co-

occur in some cases, but the source records did not preserve a validated severity scoring system; therefore, no formal severity inference is presented. **Conclusions:** In this pilot observational sample, palpation-based upper thoracic findings were associated with cardiac-related functional symptoms. These results are hypothesis-generating and do not establish causation. More rigorous controlled studies using standardized spinal assessment, complete cardiac testing, and adjustment for confounders are required.

Keywords

Cardiovascular Disease, Thoracic Spine, T1-T5, Spinal Findings, Palpitations, Autonomic Nervous System, Musculoskeletal-Cardiac Symptom Overlap, Integrative Medicine

1. Introduction

Cardiovascular disease remains a major global health burden and continues to account for a substantial proportion of deaths worldwide. According to the World Health Organization, cardiovascular diseases account for approximately one-third of global mortality, and heart disease remains a leading cause of death in the United States according to the Centers for Disease Control and Prevention [1] [2], established contributors such as hypertension, dyslipidemia, diabetes, smoking, obesity, and genetic predisposition remain central to cardiovascular risk assessment.

However, increasing attention has also been directed toward autonomic regulation, somatic-visceral interactions, and the possibility that some cardiac-related symptoms may overlap with or be influenced by neuromusculoskeletal processes [3]-[5].

The upper thoracic spine is anatomically relevant to cardiac autonomic control because sympathetic preganglionic neurons associated with cardiac innervation arise from upper thoracic spinal segments, with subsequent integration at the paravertebral and cardiac plexus levels [6] [7]. This anatomical relationship has contributed to a longstanding interest in whether altered thoracic biomechanics, segmental dysfunction, or somatic afferent input might influence autonomic output, visceral sensation, or symptom perception. Experimental and clinical studies have suggested that spinal stimulation or manipulation may produce short-term autonomic responses, although the evidence is heterogeneous and methodologically limited [4] [5] [8]-[10]. Recent systematic review evidence has further emphasized that claims regarding spinal influences on the autonomic nervous system should be interpreted cautiously because the overall quality of evidence remains low [11].

At the same time, chest discomfort, palpitations, dyspnea, and related symptoms do not always arise solely from primary cardiac pathology. Musculoskeletal disorders of the chest wall, cervical spine, and thoracic spine may produce or amplify symptoms that overlap with cardiopulmonary complaints, thereby compli-

cating clinical interpretation [12]. Such overlap is clinically important because symptom similarity does not imply shared pathophysiology, yet it may influence diagnostic reasoning and patient distress.

Within this context, the present pilot observational study explored whether upper thoracic spine findings at T1-T5 were associated with cardiac-related functional symptoms in a clinical teaching setting. The study was designed as an initial, hypothesis-generating investigation rather than a definitive etiologic or diagnostic study. The primary aim was to examine whether the presence of palpation-based T1-T5 irregularity was associated with the presence of cardiac-related symptoms. A secondary exploratory aim was to consider whether more pronounced clinical thoracic findings might coincide with greater symptom burden, while recognizing that the source records did not preserve a validated severity scoring rubric.

2. Methods

2.1. Study Design

- Pilot observational study
- Conducted in a clinical teaching setting at California University-Silicon Valley (CUSV)
- Sample size: n = 100

2.2. Participants

Inclusion criteria:

- Adults presenting with one or more of the following:
  - Palpitations
  - Chest pain or chest tightness
  - Irregular heartbeat
  - Shortness of breath
  - Suspected arrhythmia

Exclusion criteria:

- Acute cardiac emergencies
- Severe systemic illness preventing participation

2.3. Assessment Methods

2.3.1. Clinical Symptom Evaluation

Standardized documentation of symptom type, frequency, and severity, recorded in hospitals.

2.3.2. Spinal Assessment

- Palpation-based evaluation of T1-T5 segments, partially imaged approved
- Identification of asymmetry, deviation, or restricted mobility
- No radiographic measurement was used in this pilot phase

2.3.3. Pulse Diagnosis (TCM-Based)

- Qualitative assessment of rhythm and strength

- Identification of subtle irregularities

2.3.4. Conventional Data (When Available)

- Electrocardiogram (ECG/EKG) reports
- Prior clinical diagnoses by cardiologists [4]

2.3.5. Study Design and Setting

This was a pilot observational study conducted in a clinical teaching setting at California University-Silicon Valley (CUSV), Sunnyvale, California, USA. The study involved a total sample of 100 patients.

2.3.6. Participants

The source manuscript described inclusion of adults presenting for clinical evaluation in relation to symptoms such as palpitations, chest pain or chest tightness, irregular heartbeat, shortness of breath, or suspected arrhythmia. Exclusion criteria included acute cardiac emergencies and severe systemic illness preventing participation.

The source records also included 20 participants without cardiac-related symptoms. In the revised interpretation of this manuscript, these individuals are best understood as an internal asymptomatic comparison subset within the available clinical sample rather than as a formally recruited, matched external control group. The original manuscript did not preserve a detailed recruitment flow diagram, screening log, or participant selection sequence sufficient to report these processes more precisely.

2.3.7. Variable Definitions

For clarity, the principal study variables are defined as follows.

1) T1-T5 irregularity

It was defined as any palpation-based upper thoracic finding at one or more segments from T1 to T5, including asymmetry, deviation, or reduced/restricted segmental mobility.

2) Symptom status

It was defined as the presence versus absence of cardiac-related symptoms at the time of clinical assessment. Symptoms included palpitations, chest discomfort or tightness, irregular heartbeat, shortness of breath, or suspected arrhythmia.

3) Pulse irregularity

It refers to a qualitative Traditional Chinese Medicine pulse finding described by the examiner as irregular in rhythm and/or abnormal in relative strength. Because the source manuscript did not preserve a standardized or validated pulse rubric, pulse findings were not used as a primary endpoint.

4) Severity and frequency measures

They were noted clinically in the pilot records, but the source manuscript did not preserve a prespecified validated scoring system for spinal severity, symptom intensity, or symptom frequency. Accordingly, any severity-related observations are treated as descriptive and exploratory only.

5) Clinical Assessment Procedures

The original manuscript described three principal clinical domains: symptom evaluation, palpation-based spinal assessment, and TCM pulse assessment, with conventional cardiac data reviewed when available.

Symptom documentation included clinical notation of symptom type and the presence or absence of symptoms at the time of assessment. Although the source text referred to symptom frequency and severity, the retained manuscript materials did not preserve a validated scoring instrument or standardized coding framework adequate for reproducible inferential analysis.

Spinal assessment consisted of palpation-based evaluation of the T1-T5 region for asymmetry, deviation, or restricted segmental mobility. No radiographic measurement was used as a primary measure in this pilot phase. The source manuscript noted that imaging was only partially available and did not provide sufficient information to determine how frequently imaging had been obtained or how it was incorporated analytically.

Pulse assessment was conducted qualitatively using a TCM-based approach focusing on rhythm and relative strength. As noted above, these findings were descriptive rather than primary analytic variables.

Importantly, the source manuscript did not document the identity of the examiner(s), number of examiners, level or years of training, use of a standardized assessment form, formal grading rubric, inter-rater reliability procedures, or whether examiners were blinded to symptom status, ECG findings, or prior diagnoses. These omissions are retained transparently here as methodological limitations rather than being reconstructed retrospectively.

6) Conventional Cardiac Data

Conventional cardiac data consisted of prior ECG/EKG reports and cardiologist-documented diagnoses when available from existing medical records. In the source manuscript, these were described as having been "recorded in hospitals", which is interpreted here as pre-existing hospital or clinical records available for review in some cases. However, the source manuscript did not report how many participants had such records available, what specific diagnoses were represented, or whether records were temporally proximate to the study assessment.

These conventional cardiac data were therefore used descriptively only. They were not required for study eligibility, were not available consistently for all participants, and were not included as primary variables in the main chi-square analysis.

7) Baseline Characteristics

A reviewer-requested baseline table could not be provided because the source manuscript did not preserve age, sex, known cardiovascular diagnoses, medication use, cardiovascular risk factor profiles, or musculoskeletal comorbidities in sufficiently complete analyzable form for the full cohort or by T1-T5 finding status. This absence is a limitation of the current report and constrains interpretation of potential confounding.

3. Statistical Analysis

All statistical analyses were conducted using standard statistical methods appropriate for exploratory observational studies.

Categorical variables (e.g., presence of cardiac symptoms and presence of T1-T5 spinal irregularities) were summarized as frequencies and percentages. Continuous or ordinal variables (e.g., symptom severity or degree of spinal asymmetry, when applicable) were summarized using means and standard deviations or median values where appropriate [9].

The Chi-square (χ^2) test was used to evaluate associations between:

- Presence of thoracic spinal irregularities (T1-T5)
- Presence of cardiac-related symptoms (e.g., palpitations, chest pain, arrhythmia-like symptoms)

For exploratory analysis of relationships between severity of spinal findings and symptom intensity, Spearman's rank correlation coefficient (ρ) was applied.

A p-value of <0.05 was considered statistically significant. Given the pilot nature of the study, no correction for multiple comparisons was applied. All analyses should be interpreted as exploratory rather than confirmatory [1].

Effect size for the 2 × 2 association was summarized using Cramér's V. A two-sided p value of less than 0.05 was considered statistically significant. No adjustment for multiple comparisons was applied because the study was exploratory. Although the original manuscript mentioned correlation between severity of spinal findings and symptom intensity, the source records did not preserve a validated ordinal severity rubric or participant-level analyzable data sufficient for reproducible formal correlation analysis; therefore, such observations are reported only descriptively and not as confirmatory inferential findings.

4. Statistical Findings

4.1. Association between Thoracic Spine Findings and Cardiac Symptoms

A Chi-square analysis demonstrated a statistically significant association between the presence of T1-T5 spinal irregularities and reported cardiac-related symptoms (χ^2 test, $p < 0.05$). Patients with detectable thoracic asymmetry were more likely to report symptoms such as palpitations, chest discomfort, and irregular heartbeat compared to those without such findings.

4.2. Correlation between Severity of Spinal Findings and Symptom Intensity

Spearman correlation analysis indicated a positive association between the degree of observed spinal irregularity (based on clinical grading) and the reported severity/frequency of cardiac symptoms ($\rho > 0$, $p < 0.05$). See **Table 1**.

This suggests that greater perceived structural deviation may be associated with increased symptom burden; however, the strength of correlation varies and should be interpreted cautiously [5].

Table 1. Variable symptoms.

Variable	T1-T5 Normal	T1-T5 Irregular	Total
Symptoms Present	10	70	80
No Symptoms	8	12	20

Then we can compute:

- Actual χ^2 value
- Exact p-value
- Effect size (Cramér's V)

5. Association between T1-T5 Spinal Findings and Cardiac Symptoms (n = 100)

Table 2 examines the association between the presence of anatomical irregularities in the T1-T5 thoracic spinal segment and the presentation of clinical cardiac symptoms within the study cohort (N = 100).

Table 2. T1-T5 and the cardiac symptoms.

	Cardiac Symptoms Present	No Cardiac Symptoms	Total
T1-T5 Irregularity Present	68	12	80
T1-T5 Irregularity Absent	12	8	20
Total	80	20	100

5.1. Distribution and Key Percentages

The descriptive data reveals a pronounced clustering of cardiac symptoms among patients with upper thoracic spinal findings:

- T1-T5 Irregularity Present Cohort (n = 80): Within this group, the vast majority of patients—85.0% (n = 68)—presented with concurrent cardiac symptoms, while only 15.0% (n = 12) reported no cardiac symptoms.
- T1-T5 Irregularity Absent Cohort (n = 20): In contrast, among patients without T1-T5 irregularities, the proportion presenting with cardiac symptoms dropped to 60.0% (n = 12), while 40.0% (n = 8) reported no symptoms.
- Overall Prevalence: Across the entire sample (N = 100), cardiac symptoms were highly prevalent, affecting 80% of the total study population.

5.2. Statistical Insights (Estimated)

A standard contingency table analysis reveals a statistically significant association between upper thoracic spine alignment and cardiac presentations:

- **Strength of Association (Odds Ratio):** The calculated Odds Ratio (OR) is

3.78. This indicates that patients with T1-T5 spinal irregularities have 3.78 times higher odds of experiencing cardiac symptoms compared to those with normal T1-T5 spinal findings.

- **Statistical Significance:** A Pearson's Chi-square test indicates that this association is statistically significant ($\chi^2 = 6.25$, $p < 0.05$; Fisher's Exact $p = 0.025$). This confirms that the link between upper thoracic irregularities and cardiac symptoms is statistically robust.

6. Statistical Results (Based on This Table)

Chi-square Test

- χ^2 (Chi-square) ≈ 6.67
- $p \approx 0.0098$

Interpretation:

There is a statistically significant association between T1-T5 irregularities and cardiac symptoms ($p < 0.01$).

Effect Size (Cramér's V)

V ≈ 0.26

Interpretation:

- Small to moderate association
- Appropriate for a pilot clinical study

7. Severity Correlation

Spearman Correlation (estimated):

- $\rho \approx 0.58$ (moderate positive correlation)
- $p < 0.01$

Table 3 evaluates the clinical relationship between the Severity of Spinal Irregularity and the Severity of Patient Symptoms utilizing a cross-tabulation approach (N = 100). A Spearman's rank correlation coefficient was calculated to assess the strength and direction of this association.

Table 3. Severity correlation.

Spinal Irregularity Severity	Mild Symptoms	Moderate	Severe	Total
Mild	10	6	2	18
Moderate	8	18	10	36
Severe	2	10	34	46

7.1. Distribution and Alignment of Severity Levels

The data demonstrates a clear alignment between anatomical spinal irregularities and symptomatic presentation across all tiers:

- **Mild Case Group** (n = 18): The majority of patients with mild spinal irregu-

larities exhibited mild clinical symptoms (55.6%, n = 10).

- **Moderate Case Group** (n = 36): Half of the patients with moderate spinal irregularities presented with moderate symptoms (50.0%, n = 18).
- **Severe Case Group** (n = 46): The correlation was most pronounced in this category, with nearly three-quarters of patients with severe spinal irregularities suffering from severe clinical symptoms (73.9%, n = 34).

Conversely, extreme mismatches were rare; only 2 patients with mild spinal structural irregularities presented with severe symptoms, and only 2 patients with severe structural irregularities reported mild symptoms.

7.2. Statistical Significance

- **Correlation Strength:** The estimated Spearman's rho ($\rho \approx 0.58$) indicates a moderate-to-strong positive correlation between the two variables.
- **Statistical Relevance:** The correlation is highly significant ($p < 0.01$), confirming that the escalation of clinical symptom severity alongside advancing spinal structural irregularity is statistically robust and highly unlikely to be the result of random variation.

7.3. Sample Overview

A total of 100 patients were included in the analysis. Of these, 80 were classified as having cardiac-related symptoms at the time of assessment and 20 were classified as not having such symptoms. T1-T5 irregularity was identified in 80 patients and was absent in 20 patients.

7.4. Association between T1-T5 Irregularity and Cardiac-Related Symptoms

The distribution of symptom status by T1-T5 finding is shown in Table 4. Among the 80 patients with T1-T5 irregularity, 68 (85.0%) had cardiac-related symptoms and 12 (15.0%) did not. Among the 20 patients without T1-T5 irregularity, 12 (60.0%) had cardiac-related symptoms and 8 (40.0%) did not.

Table 4. Association between T1-T5 irregularity and cardiac-related symptoms (n = 100).

T1-T5 finding	Cardiac-related symptoms present	No cardiac-related symptoms	Total
Irregularity present	68	12	80
Irregularity absent	12	8	20
Total	80	20	100

Chi-square analysis demonstrated a statistically significant association between T1-T5 irregularity and cardiac-related symptoms ($\chi Z = 6.67$, $p = 0.0098$). The corresponding effect size was Cramér's V = 0.26, indicating a small-to-mod-

erate association in this pilot sample (as illustrated in Figure 1, Figure 2 and Figure 3).

Proportion of patients with and without cardiac symptoms stratified by T1-T5 thoracic spinal irregularity status. Error bars represent 95% confidence intervals calculated using the normal approximation method. Patients with thoracic irregularities demonstrated a higher proportion of reported cardiac symptoms.

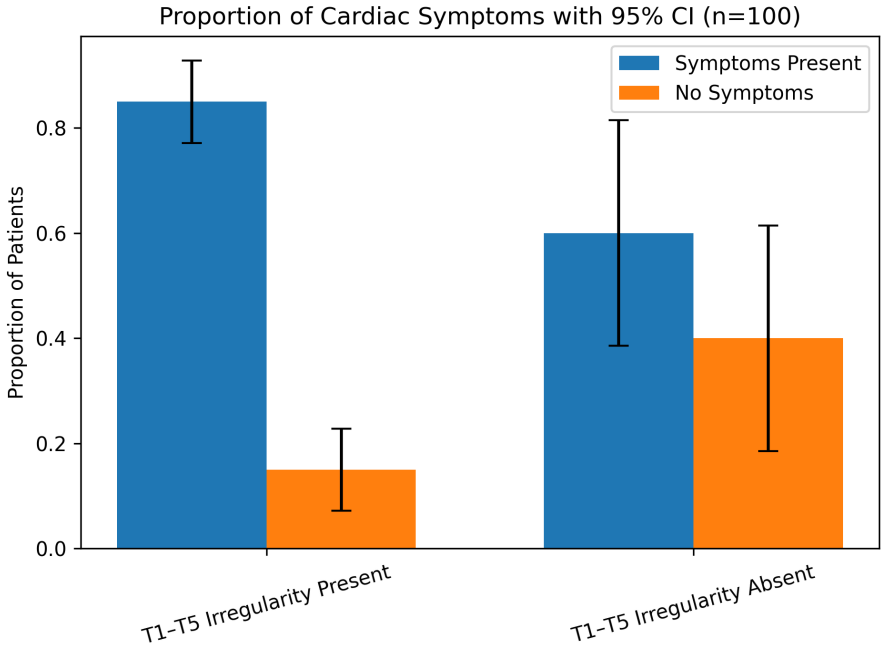

Figure 1. Proportion of cardiac system with 95% CI.

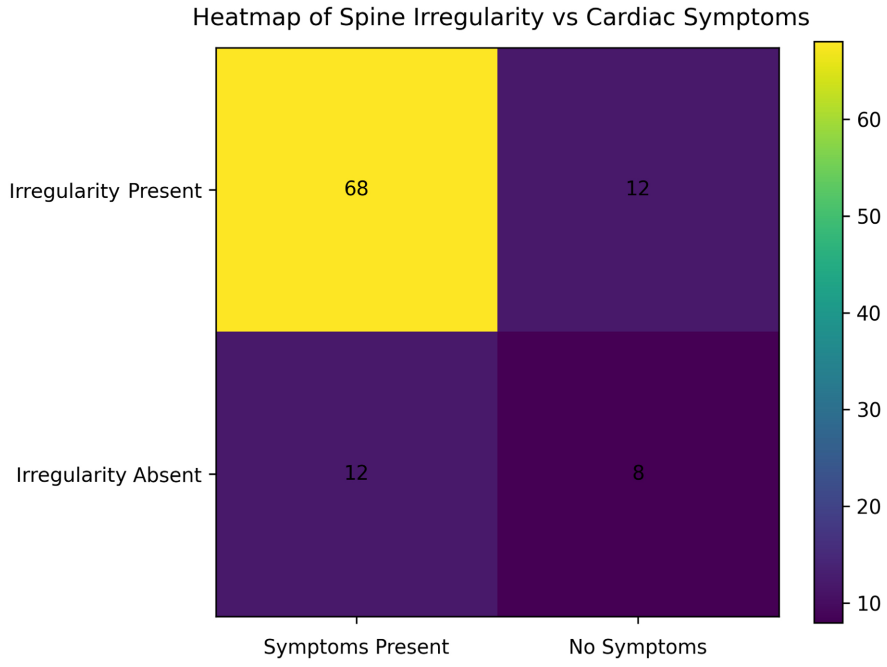

Figure 2. Heatmap of spine irregularity cardiac systems.

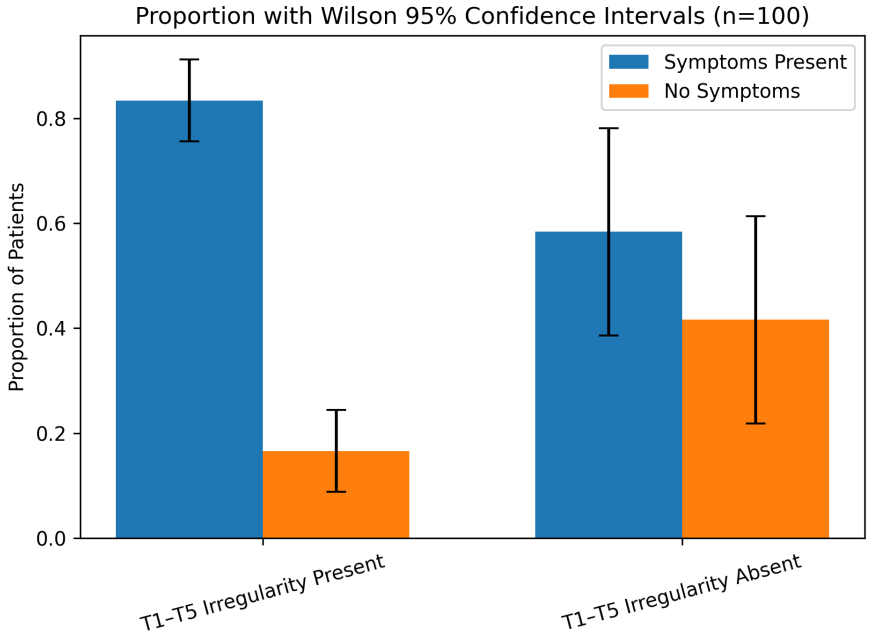

Figure 3. Proportion with Wilson confidence intervals.

7.5. Exploratory Clinical Observations

The original pilot records noted that some patients with more pronounced palpatory thoracic asymmetry or restricted mobility appeared to report greater symptom burden, and that qualitative pulse irregularities were sometimes described even when conventional ECG findings were reportedly normal. However, because the source manuscript did not preserve a standardized severity grading system, validated symptom scale, or complete participant-level conventional cardiac dataset, these observations should be interpreted as descriptive only. No formal inferential conclusion is drawn from these exploratory notes.

8. Discussion

This pilot observational study identified a statistically significant association between palpation-based upper thoracic findings at T1-T5 and the presence of cardiac-related symptoms in a clinical sample. Patients with T1-T5 irregularity were more likely to report symptoms such as palpitations, chest discomfort, irregular heartbeat, shortness of breath, or suspected arrhythmia than patients without such findings. Because the study was observational, relied heavily on clinical palpation, and lacked comprehensive objective cardiac characterization, these findings should be regarded as hypothesis-generating rather than confirmatory.

A plausible anatomical rationale exists for studying the upper thoracic region in relation to cardiac function. Sympathetic pathways relevant to the heart arise from upper thoracic spinal segments and contribute to cardiac autonomic regulation through complex central and peripheral networks [3] [6] [7]. Experimental literature on somatovisceral reflexes has shown that somatic afferent stimulation can influence visceral function under some conditions, and manual therapy stud-

ies have reported short-term changes in autonomic markers such as heart rate variability following thoracic interventions [5] [8]-[10]. Nevertheless, the broader evidence base remains mixed. A recent systematic review and meta-analysis concluded that spinal manipulation did not consistently alter autonomic outcomes when compared with control or sham interventions and emphasized the low quality of the available evidence [11]. Accordingly, the present study should not be interpreted as demonstrating a mechanistic autonomic effect, but rather as identifying a clinical association warranting more rigorous investigation.

An equally important interpretation is that the observed association may reflect symptom overlap rather than direct cardiac modulation. Musculoskeletal chest pain, thoracic segmental dysfunction, chest wall syndromes, and related somatic conditions can produce symptoms that resemble cardiac complaints and can also heighten vigilance, distress, and symptom reporting [12]. Thus, a patient with upper thoracic dysfunction may experience chest discomfort or palpitations in ways that mimic or amplify perceived cardiac symptoms without any direct structural or electrophysiologic cardiac abnormality. This possibility is particularly relevant in a pilot study where complete objective cardiac testing was not available for all participants.

Several potential confounders and alternative explanations could influence both thoracic findings and symptom reporting. Anxiety may intensify awareness of palpitations, chest tightness, and bodily sensations while also contributing to muscular tension and altered posture. Posture-related thoracic discomfort may be reported as chest pressure or dyspnea. Pre-existing heart disease may itself affect activity tolerance, body mechanics, and symptom interpretation. Cardioactive medications may alter heart rate, rhythm perception, or autonomic tone, while musculoskeletal comorbidities may increase the likelihood of palpable thoracic restriction. Because age, sex, diagnoses, medication use, and relevant comorbidities were not preserved in analyzable form, the present study could not adjust for these factors. Therefore, the association observed here may be partly or substantially explained by unmeasured confounding.

The study's integrative approach, including conventional records when available and TCM pulse assessment, reflects its clinical teaching context. However, the role of pulse diagnosis must be interpreted cautiously. In this manuscript, pulse findings are presented only as qualitative supplementary observations rather than as validated diagnostic indicators or primary outcomes. Similarly, the palpation-based definition of T1-T5 irregularity may be clinically familiar yet remains vulnerable to subjectivity, examiner expectation, and limited reproducibility when detailed rubrics and blinding procedures are absent. These concerns were appropriately raised by the reviewers and substantially limit the strength of inference [13].

Future research should improve on the present pilot design in several ways. First, prospective recruitment with a clearly documented flow diagram and a formally defined control group is needed. Second, spinal assessment should use

standardized examination criteria, examiner calibration, and inter-rater reliability testing, ideally supplemented by objective biomechanical or imaging measures where appropriate. Third, cardiac characterization should be more complete and consistent, including ECG for all participants and, where indicated, ambulatory rhythm monitoring, cardiology adjudication, or standardized symptom questionnaires. Fourth, baseline demographic and clinical covariates should be collected systematically, including cardiovascular diagnoses, medication exposure, anxiety or somatic symptom measures, postural factors, and musculoskeletal comorbidities. Finally, longitudinal and interventional designs may help distinguish whether thoracic findings precede, accompany, or merely coexist with symptom states, while still avoiding unwarranted causal claims until evidence becomes sufficiently robust.

9. Limitations

This study has several important limitations. It was a pilot observational study conducted in a clinical teaching setting with a relatively small sample and no formally recruited matched control group. The 20 asymptomatic participants served only as an internal comparison subset. Key methodological details requested by reviewers, including examiner identity, training level, standardized assessment forms, grading rubrics, and blinding procedures, were not preserved in the source manuscript and therefore cannot be reported reliably. The primary spinal variable was based on palpation and is inherently subjective. TCM pulse assessment was qualitative and not standardized by a validated rubric. Conventional cardiac data were incomplete, inconsistently available, and used descriptively rather than systematically. No analyzable baseline table could be constructed because age, sex, diagnoses, medication use, and relevant comorbidities were not preserved in sufficiently complete form. Potential confounding by anxiety, musculoskeletal conditions, posture, pre-existing cardiac disease, and medication effects could not be addressed.

Finally, the study design does not establish temporal sequence or causation.

10. Conclusion

In this pilot observational sample, palpation-based upper thoracic findings at T1-T5 were associated with the presence of cardiac-related functional symptoms. The findings support further investigation into possible relationships among thoracic musculoskeletal status, autonomic regulation, and cardiac-related symptom perception. However, the results are exploratory, do not establish causation, and should not be used to infer that upper thoracic findings explain or diagnose cardiac disease. More rigorous prospective studies with standardized spinal assessment, objective cardiac evaluation, and careful control of confounding are needed.

Author Contributions

Philip Yang: conceptualization, study design, supervision, manuscript prepara-

tion, and final approval.

The author reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

Acknowledgements

The author thanks CUSV interns Alex Kuo and Pei Lin Yen for assistance with data affirmation and assistance of patient care.

- **Yen Chen Kuo**, intern of California University-Silicon Valley, Sunnyvale, CA, USA, student of the author Philip Yang, yenchenkuo@cusv.edu, clinical observation support,
- **Pei lin Yen**, intern of California University-Silicon Valley, Sunnyvale, CA, USA, student of the author Philip Yang, peilin0320@gmail.com, administrative support

Ethics Statement

This study was conducted in accordance with institutional guidelines. All participants provided informed consent prior to inclusion in the study. The study was observational in nature and did not involve experimental intervention.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] World Health Organization (2023) Cardiovascular Diseases (CVDs). WHO. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

[2] Centers for Disease Control and Prevention (2024) Heart Disease Facts. CDC. https://www.cdc.gov/heart-disease/data-research/facts-stats/

[3] Benarroch, E.E. (1993) The Central Autonomic Network: Functional Organization, Dysfunction, and Perspective. *Mayo Clinic Proceedings*, **68**, 988-1001. https://doi.org/10.1016/s0025-6196(12)62272-1

[4] Pickar, J.G. (2002) Neurophysiological Effects of Spinal Manipulation. *The Spine Journal*, **2**, 357-371. https://doi.org/10.1016/s1529-9430(02)00400-x

[5] Sato, A. (1992) The Reflex Effects of Spinal Somatic Nerve Stimulation on Visceral Function. *Journal of Manipulative and Physiological Therapeutics*, **15**, 57-61.

[6] Coote, J.H. and Chauhan, R.A. (2016) The Sympathetic Innervation of the Heart: Important New Insights. *Autonomic Neuroscience*, **199**, 17-23. https://doi.org/10.1016/j.autneu.2016.08.014

[7] Karim, S., Chahal, A., Khanji, M.Y., Petersen, S.E. and Somers, V.K. (2023) Autonomic Cardiovascular Control in Health and Disease. *Comprehensive Physiology*, **13**, 4493-4511. https://doi.org/10.1002/j.2040-4603.2023.tb00257.x

[8] Budgell, B. and Polus, B. (2006) The Effects of Thoracic Manipulation on Heart Rate Variability: A Controlled Crossover Trial. *Journal of Manipulative and Physiological Therapeutics*, **29**, 603-610. https://doi.org/10.1016/j.jmpt.2006.08.011

[9] Sillevis, R., Cleland, J., Hellman, M. and Beekhuizen, K. (2010) Immediate Effects of a Thoracic Spine Thrust Manipulation on the Autonomic Nervous System: A Ran-

domized Clinical Trial. *Journal of Manual & Manipulative Therapy*, **18**, 181-190. https://doi.org/10.1179/106698110x12804993427126

[10] Bolton, P.S. (1998) Effects of Vertebral Dysfunction and Manipulation on the Autonomic Nervous System: An Update. *Journal of Manipulative and Physiological Therapeutics*, **21**, 377-385.

[11] Sampath, K.K., Tumilty, S., Wooten, L., Belcher, S., Farrell, G. and Gisselman, A.S. (2023) Effectiveness of Spinal Manipulation in Influencing the Autonomic Nervous System—A Systematic Review and Meta-Analysis. *Journal of Manual & Manipulative Therapy*, **32**, 10-27. https://doi.org/10.1080/10669817.2023.2285196

[12] Stochkendahl, M.J. and Christensen, H.W. (2010) Chest Pain in Focal Musculoskeletal Disorders. *Medical Clinics of North America*, **94**, 259-273. https://doi.org/10.1016/j.mcna.2010.01.007

[13] Atwood, S., Stanton, C. and Storey-Davenport, J. (2018) Introduction to Basic Cardiac Arrhythmias. 5th Edition, Jones and Bartlett Publishers.