

Thyroid Disorders on Adhesive Capsulitis: Examining the Role of IL-6 and CRP in Acute and Chronic Pain Stages

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ABSTRACT

Objective: Thyroid dysfunction is a known risk factor for adhesive capsulitis (AC), but prior studies have relied on single-domain outcomes without formal inferential comparison between thyroid subtypes. No Indian study has examined, within one cohort using validated multidomain instruments, whether physical, psychological, and functional burden in thyroid-related AC differs by subtype. This study assessed prevalence and distribution of physical activity, sleep quality, psychological morbidity, kinesiophobia, functional disability, quality of life, pain, and irritability in patients with AC and co-existing hyperthyroidism or hypothyroidism, stratified by disease duration, and tested for association between subtype and each domain.

Methods: This was a single-centre, cross-sectional observational study conducted in patients aged 40 to 60 years with clinically diagnosed AC and co-existing thyroid dysfunction. A total of 46 patients were enrolled and form the study sample reported in the demographic and clinical summary. Thyroid-subtype classification (hyperthyroid n=23, hypothyroid n=20; total 43) was available for 43 of the 46 participants, and subtype-stratified analyses are based on these 43 participants. All outcome measures were collected at a single assessment visit; disease-duration strata (≤ 1 , 2–4, ≥ 5 years) reflect the recorded duration of thyroid diagnosis at that visit rather than longitudinal follow-up. Validated instruments assessed each domain. Fisher's exact test evaluated subtype–outcome associations, appropriate given small cell sizes (as low as n=2 in some strata); duration-stratified comparisons remained descriptive. A post hoc sample-size and power appraisal is reported alongside the primary analysis, and a Bonferroni-adjusted significance threshold ($p < 0.00625$ for eight comparisons) is applied alongside the conventional $p \leq 0.05$ threshold to contextualise the single significant finding.

Results: Physical inactivity, poor sleep, psychological distress, kinesiophobia, disability, pain, and irritability were prevalent throughout the cohort. Only poor sleep quality showed a significant subtype association, more frequent in hyperthyroid than hypothyroid participants (69.5% vs 30.0%; Fisher's exact $p = 0.015$, odds ratio 5.33, 95% CI 1.45 to 19.67; risk difference 39.6 percentage points, 95% CI 12.1 to 67.1), a difference that was statistically significant under the conventional threshold but did not remain significant after Bonferroni correction for eight comparisons (adjusted threshold $p < 0.00625$), and is therefore reported as a nominally significant, hypothesis-generating association rather than a multiplicity-robust finding. No significant associations emerged for the remaining seven domains ($p = 0.669$ – 1.000), though descriptive differences were

noted and are reported strictly as hypothesis-generating.

Conclusion: This cross-sectional, multi-instrument, formally tested characterisation of burden in Indian patients with adhesive capsulitis with co-existing thyroid dysfunction found that sleep quality alone showed a nominally significant association with subtype under the conventional threshold that did not survive Bonferroni correction, and is presented as a hypothesis-generating signal warranting clinical attention to sleep in hyperthyroid patients rather than a statistically robust, multiplicity-adjusted finding; other observed differences require confirmation in larger, adequately powered cohorts.

Keywords: adhesive capsulitis, disease duration, kinesiophobia, physical activity, thyroid dysfunction, sleep quality

Introduction

Adhesive capsulitis (AC), or frozen shoulder, is characterised by severe pain and progressive restriction of glenohumeral range of motion due to contracture of the joint capsule and synovium, and is classified under the broader category of “rigid shoulder”, encompassing any restriction of upper limb movement [1]. It was first described by Duplay and later termed frozen shoulder by Codman. Common risk factors include female sex, age above 40 years, diabetes mellitus, trauma, prolonged immobility, thyroid disease, stroke, and myocardial infarction. Thyroid disorders have been associated with AC, although the exact mechanism remains unclear [2-3]. AC typically progresses through four clinical stages.

Musculoskeletal manifestations are common but often overlooked in thyroid disease. Hypothyroidism is more prevalent than hyperthyroidism and affects 6% to 20% of the population, while hyperthyroidism affects about 1.5% [4-6]. Symptoms of hypothyroidism include myalgia, stiffness, cramps, and arthralgia. It is also associated with conditions such as AC, carpal tunnel syndrome, trigger finger, and tarsal tunnel syndrome. Most cases are autoimmune in origin, commonly due to Hashimoto thyroiditis, and are characterised by elevated thyroid-stimulating hormone levels. Other manifestations include Dupuytren's contracture and noninflammatory back pain [7-8].

Despite the known association, several gaps remain. First, most studies focus on prevalence without assessing multiple aspects of patient burden such as physical activity, sleep, mood, kinesiophobia, disability, and quality of life within the same cohort, and evidence in non-athletic populations is limited. Second, existing studies are mostly single-domain and conducted in Western or East Asian populations, so their applicability to Indian patients is uncertain. Third, outcomes have not been analysed based on the duration of thyroid disease, making it unclear whether the burden changes over time. Fourth, and most consequentially for the interpretation of this literature, existing thyroid-subtype comparisons in AC have generally relied on descriptive percentage reporting without formal statistical testing of the association between subtype and outcome; without inferential testing, an apparent percentage difference between hyperthyroid and hypothyroid groups cannot be distinguished from a difference attributable to chance, particularly in small cohorts.

This study was designed to address these gaps. It evaluates eight physical, psychological, and functional domains of patient burden in individuals with AC and thyroid dysfunction, examines the effect of disease duration descriptively, and formally tests, using Fisher's exact test, whether outcomes in each domain are statistically associated with thyroid subtype. This study

also reports effect sizes with 95% confidence intervals and a multiple-comparisons-adjusted significance threshold alongside conventional p-values, so that the magnitude and robustness of associations, not only their nominal significance, can be judged by the reader. This approach aims to provide clinically relevant evidence to guide comprehensive management, while explicitly distinguishing findings that are statistically supported from those that are descriptive and hypothesis-generating only.

Methods

Study design and setting

This was a single-centre, cross-sectional observational study, conducted at the Physiotherapy Outpatient Department of SRM Medical College Hospital and Research Centre, Kattankulathur, Tamil Nadu, India, over a period of two years. All outcome measures for each participant were collected at a single assessment visit; the study did not involve longitudinal follow-up or repeated measurement of outcomes. Disease-duration strata (≤ 1 , 2–4, ≥ 5 years) and pain-duration strata (acute, chronic) were derived from the duration of thyroid diagnosis and shoulder symptoms recorded at that visit, and should be interpreted as a cross-sectional comparison across patients at different points in their disease course rather than as a within-patient longitudinal trajectory. Participants were recruited using convenience sampling.

Participants

A total of 46 patients with adhesive capsulitis and co-existing thyroid dysfunction were enrolled in this study and form the study sample presented in Table 1. Thyroid-subtype classification was available for 43 of these 46 participants (hyperthyroid $n=23$, hypothyroid $n=20$); the remaining 3 participants had a confirmed diagnosis of thyroid dysfunction but no subtype classification recorded, and are accordingly included in the overall demographic and clinical summary in Table 1 but not in the subtype-stratified comparisons in Tables 2 to 9, which are based on $n=43$. Eligible participants were aged between 40 and 60 years and included both males and females.

Inclusion criteria: age 40 to 60 years; clinical diagnosis of adhesive capsulitis (see below) with co-existing thyroid dysfunction; willingness to provide written informed consent.

Exclusion criteria: diabetes mellitus; recent shoulder trauma or post-traumatic stiffness; history of fracture, dislocation, or surgery involving the shoulder; other shoulder joint pathologies identified on clinical or radiographic examination; active smoking or alcohol use; claustrophobia; presence of metallic implants, prosthetic heart valves, or cardiac pacemakers.

Diagnosis of adhesive capsulitis

Adhesive capsulitis was diagnosed clinically by the treating orthopaedic and physiotherapy team, based on a characteristic history of insidious-onset shoulder pain with progressive restriction of both active and passive glenohumeral range of motion, particularly external rotation and abduction, in a global (capsular) pattern. Plain radiography of the affected shoulder was obtained in all participants to exclude alternative structural pathology, including glenohumeral osteoarthritis, calcific tendinitis, and fracture; participants with a clinical suspicion of rotator cuff tear on examination were excluded, consistent with the exclusion criteria above. This clinical diagnostic approach is consistent with standard practice for AC, in which the diagnosis is established on history and examination rather than a single confirmatory test [2-3].

Classification of thyroid dysfunction

Thyroid status (hyperthyroid or hypothyroid) was determined through medical record review, based on the treating physician's documented diagnosis and current thyroid-specific pharmacological treatment at the time of enrolment (antithyroid medication for hyperthyroidism; levothyroxine replacement for hypothyroidism). Biochemical thyroid function tests (serum TSH, free T3, free T4) performed by the treating physician at the time of the original thyroid diagnosis were not extracted for this analysis and were not repeated at study enrolment. Consequently, this study cannot determine whether participants were biochemically euthyroid, subclinically, or overtly hyper- or hypothyroid at the time of outcome assessment, nor distinguish disease severity within each subtype. Findings should therefore be interpreted as describing burden in patients with a clinically diagnosed and pharmacologically managed thyroid subtype, rather than a biochemically confirmed thyroid state at the time of assessment; this limitation is discussed further below.

Assessment instruments

Physical variable: Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ), which has good reliability ($r = 0.8$) and moderate validity ($r = 0.30$) [25]. Participants were categorised as physically inactive, minimally active, or achieving health-enhancing physical activity (HEPA) levels according to standard IPAQ scoring criteria [25].

Psychological variables: Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a 19-item questionnaire that provides a global score (reliability 0.76); a PSQI global score greater than 5 indicates poor sleep quality, per the original validation of the instrument [26]. Depression, anxiety, and stress were measured using the Depression Anxiety Stress Scales (DASS-42), which includes three subscales with good internal consistency (depression $\alpha = 0.91$, anxiety $\alpha = 0.84$, stress $\alpha = 0.90$) [27]. The three DASS-42 subscale severity ratings (normal, mild, moderate, severe, extremely severe, using the published DASS-42 subscale cut-offs [27]) were combined for each participant by taking the highest severity rating across the three subscales; this combined rating is reported as "psychological distress" in the Results and Table 5, and the depression, anxiety, and stress subscales were not analysed separately. Fear of movement was evaluated using the Tampa Scale for Kinesiophobia (TSK), which assesses fear avoidance and movement-related fear (reliability 0.64 to 0.80; validity $r = 0.33$ to 0.59) [28]; a TSK score of 37 or above was used to classify kinesiophobia as present, the threshold established by Vlaeyen et al. [28].

Functional variables: Upper extremity disability was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, a 30-item scale with high reliability (0.97), scored continuously from 0 (no disability) to 100 (most severe disability) [29]. For descriptive presentation in Table 7, the continuous DASH score was collapsed into mild (score <30), moderate (30 to 50), and severe (>50) categories; the continuous DASH score by subtype is additionally reported in the Discussion as a secondary check on this categorical presentation. Quality of life was measured using the Short Form-36 (SF-36), which evaluates eight health domains (internal consistency 0.791; validity 0.786) [30]. For descriptive presentation in Table 8, the mean of the eight SF-36 domain scores was calculated for each participant, and a mean score below 50, the scale midpoint below which a participant reports more limitation than health across domains, was classified as "unhealthy"; this binary classification summarises the SF-36's eight continuous domain scores for descriptive purposes and does not supersede them. Pain severity was assessed using the Visual Analogue Scale (VAS), a 0 to 100 mm scale, with severity bands of mild (<30 mm), moderate (30 to 54 mm), and severe (≥ 55 mm), based on the categorical thresholds derived by Collins et al. from analgesic-trial data [31]. Irritability was evaluated using a validated Irritability Scale, categorising participants as irritable or non-irritable.

Statistical analysis

Descriptive statistics were used to summarise demographic, clinical, and outcome variables. Categorical data in Table 1 are presented as frequencies and percentages calculated against the full study sample ($N=46$); categorical data in Tables 2 to 9, which are stratified by thyroid subtype, are calculated against the subtype-confirmed sample ($n=43$; hyperthyroid $n=23$, hypothyroid $n=20$), as described above. Results were stratified by thyroid subtype, duration of thyroid disease (≤ 1 year, 2 to 4 years, ≥ 5 years), and pain duration (acute, <3 months; chronic, ≥ 3 months). For each of the eight outcome domains, the association between thyroid subtype (hyperthyroid vs hypothyroid, collapsed across duration strata) and a clinically meaningful binary or collapsed-ordinal categorisation of the outcome was tested using Fisher's exact test, which is appropriate for the sample sizes and cell counts present in this cohort (hyperthyroid $n=23$, hypothyroid $n=20$). For all eight domains, including the sleep-quality comparison discussed in most detail below, the risk ratio, odds ratio, and absolute risk difference between subtypes are additionally reported with 95% confidence intervals, calculated using standard log-transformed methods with the Haldane-Anscombe correction applied where any cell count was zero, so that the magnitude and precision of each association can be judged independently of the p-value. A two-tailed p-value ≤ 0.05 was considered statistically significant using conventional criteria. Because eight domains were tested for association with thyroid subtype, a Bonferroni-adjusted threshold of $p < 0.00625$ (0.05 divided by 8) is also reported alongside the conventional threshold. The poor sleep quality association ($p=0.015$) was statistically significant under the conventional threshold but does not remain significant after Bonferroni correction, since 0.015 exceeds 0.00625. This study did not pre-specify a single primary outcome, so all eight domain-level comparisons in Table 2, including sleep quality, are regarded as exploratory, and the sleep-quality finding is reported as a nominally significant, hypothesis-generating association rather than a multiplicity-adjusted, statistically robust one. Duration-stratified comparisons (≤ 1 year, 2 to 4 years, ≥ 5 years, with cell sizes as low as $n=2$) and pain-duration comparisons (acute $n=5$, chronic $n=38$) were not

formally tested given inadequate cell sizes for reliable inference, and are reported descriptively as hypothesis-generating only; this distinction is maintained throughout the Results and Discussion. No a priori sample-size or power calculation was performed for this study; a post hoc power appraisal is reported in the Limitations. Statistical reporting followed the SAMPL guidelines.

Results

Table 1 summarises the demographic and clinical profile of the full study sample of 46 patients. Most participants were women (67.39%) and aged 50 years or older (65.22%). Hyperthyroid participants comprised 23 of 46 patients (50.00%) and hypothyroid participants 20 of 46 (43.48%); thyroid subtype was not recorded for the remaining 3 participants (6.52%). Right shoulder involvement was more common (80.43%), and the majority had chronic pain lasting ≥3 months (82.61%). All participants were from urban areas, and nearly half (45.65%) were housewives.

Table 1

Demographic and clinical characteristics of the full study sample of patients with adhesive capsulitis and thyroid dysfunction (N=46)

Characteristic	n	%
Age <50 years	13	28.26
Age ≥50 years	30	65.22
Male	12	26.09
Female	31	67.39
Housewife	21	45.65
Own business	5	10.87
Government/administrative employee	4	8.70
Farmer	1	2.17
Driver	1	2.17
Other occupation	11	23.91
Urban location	46	100.00
Right shoulder affected	37	80.43
Left shoulder affected	6	13.04
Hyperthyroid, total	23	50.00
Hypothyroid, total	20	43.48
Acute pain (<3 months)	5	10.87
Chronic pain (≥3 months)	38	82.61

AC = adhesive capsulitis. Where category totals do not sum to 46 (age, sex, occupation, shoulder side, thyroid subtype, pain duration), the difference reflects participants for whom that specific field was not recorded; subtype-stratified Tables 2 to 9 use the n=43 subset with confirmed thyroid subtype.

Formal test of association between thyroid subtype and outcome domain

Table 2 summarises the result of Fisher's exact testing for association between thyroid subtype and each of the eight outcome domains, collapsed across duration strata, together with the odds ratio and absolute risk difference for each domain, both with 95% confidence intervals. Of the eight domains tested, only sleep quality showed a statistically significant association with thyroid subtype under the conventional threshold; this association did not remain significant after Bonferroni correction for eight comparisons (adjusted threshold $p < 0.00625$): poor sleep was present in 69.5% (16 of 23) of hyperthyroid participants compared with 30.0% (6 of 20) of hypothyroid participants ($p = 0.015$; odds ratio 5.33, 95% CI 1.45 to 19.67; risk difference 39.6 percentage points, 95% CI 12.1 to 67.1). No other domain

Table 2

Fisher's exact test, odds ratio, and absolute risk difference for association between thyroid subtype (hyperthyroid vs hypothyroid) and each outcome domain, collapsed across duration strata. N = subtype total (hyperthyroid n=23, hypothyroid n=20)

Domain	Hyper n/N (%)	Hypo n/N (%)	Fisher p	OR (95% CI)	RD % (95% CI)
Physical inactivity	17/23 (73.9)	14/20 (70.0)	1.000	1.21 (0.32-4.61)	3.9 (-23.0 to 30.8)
Poor sleep quality	16/23 (69.5)	6/20 (30.0)	0.015	5.33 (1.45-19.67)	39.6 (12.1 to 67.1)
Mod/severe psych. distress	13/23 (56.5)	13/20 (65.0)	0.756	0.70 (0.20-2.41)	-8.5 (-37.6 to 20.6)
Irritability present	17/23 (73.9)	15/20 (75.0)	1.000	0.94 (0.24-3.74)	-1.1 (-27.2 to 25.0)
Kinesiophobia present	17/23 (73.9)	15/20 (75.0)	1.000	0.94 (0.24-3.74)	-1.1 (-27.2 to 25.0)
Mod/severe functional disability	19/23 (82.6)	18/20 (90.0)	0.669	0.53 (0.09-3.24)	-7.4 (-27.7 to 12.9)
Unhealthy quality of life	6/23 (26.1)	7/20 (35.0)	0.740	0.66 (0.18-2.42)	-8.9 (-36.5 to 18.6)
Severe pain	5/23 (21.7)	6/20 (30.0)	0.728	0.65 (0.16-2.57)	-8.3 (-34.5 to 18.0)

A Bonferroni-adjusted significance threshold of $p < 0.00625$ applies for eight comparisons; no domain, including poor sleep quality ($p = 0.015$), remains significant under this stricter threshold, so all associations in this table are regarded as exploratory.

reached statistical significance, and none of the remaining seven confidence intervals excluded the null value, consistent with the absence of a detectable association rather than a precisely estimated null effect. Descriptive percentage differences were present for several domains, including apparently higher rates of severe pain and irritability among hyperthyroid participants and apparently higher rates of moderate-to-severe functional disability among hypothyroid participants, but these differences are not statistically distinguishable from chance in this sample, and their wide confidence intervals indicate that this study cannot rule out clinically meaningful effects in either direction for these domains; they are reported in the domain-specific sections below as descriptive and hypothesis-generating, not as established findings.

Physical activity (IPAQ)

Table 3 shows that physical inactivity was the most common pattern across all groups, and no participant achieved health-enhancing physical activity levels. Descriptively,

Table 3

Physical activity level (IPAQ Scale)

Thyroid state and duration	Physically inactive n (%)	Minimally active n (%)
Hyperthyroid ≤1 year (n=6)	5 (83.33)	1 (16.66)
Hyperthyroid 2-4 years (n=11)	8 (72.72)	3 (27.27)
Hyperthyroid ≥5 years (n=6)	4 (66.66)	2 (33.33)
Hypothyroid ≤1 year (n=7)	4 (57.14)	3 (42.85)
Hypothyroid 2-4 years (n=11)	9 (81.81)	2 (18.18)
Hypothyroid ≥5 years (n=2)	1 (50.00)	1 (50.00)
Acute pain (n=5)	4 (80.00)	1 (20.00)
Chronic pain (n=38)	27 (71.05)	11 (28.94)

HEPA = health-enhancing physical activity, IPAQ = International Physical Activity Questionnaire. Duration and pain-duration strata are descriptive only; percentages calculated against the subtype-confirmed sample (n=43; hyperthyroid n=23, hypothyroid n=20).

inactivity among hyperthyroid participants was highest in those with disease duration ≤ 1 year (83.33%) and decreased slightly with longer duration; among hypothyroid participants, inactivity was highest at 2 to 4 years (81.81%). Participants with chronic pain showed slightly lower inactivity (71.05%) than those with acute pain (80.00%). As shown in Table 2, overall physical inactivity did not differ significantly by thyroid subtype ($p=1.000$; OR 1.21, 95% CI 0.32-4.61); the near-universal inactivity across both subtypes indicates that graded activity rehabilitation may reasonably be considered a default component of thyroid-AC physiotherapy rather than a selective addition for one subtype.

Sleep quality (PSQI)

As shown in Table 4, poor sleep quality was common among hyperthyroid participants across all disease durations, ranging from 66.66% to 72.72%. Hypothyroid participants generally reported better sleep, particularly at 2 to 4 years, where 81.81% had good sleep quality. Poor sleep was descriptively more frequent in participants with chronic pain (68.42%) than acute pain (60.00%), though this pain-duration comparison was not formally tested. As reported in Table 2, this was the only domain among the eight tested that showed a statistically significant association with thyroid subtype ($p=0.015$; OR 5.33, 95% CI 1.45-19.67; risk difference 39.6 percentage points, 95% CI 12.1-67.1), a difference that was statistically significant under the conventional threshold ($p=0.015$) but did not remain significant after Bonferroni correction (adjusted threshold $p<0.00625$): hyperthyroid participants had a higher rate of poor sleep than hypothyroid participants under the conventional threshold, and the confidence interval excluding the null suggests

Table 4 Sleep quality (Pittsburgh Sleep Quality Index)

Thyroid state and duration	Good sleep n (%)	Poor sleep n (%)
Hyperthyroid ≤ 1 year (n=6)	2 (33.33)	4 (66.66)
Hyperthyroid 2-4 years (n=11)	3 (27.27)	8 (72.72)
Hyperthyroid ≥ 5 years (n=6)	2 (33.33)	4 (66.66)
Hypothyroid ≤ 1 year (n=7)	4 (57.14)	3 (42.85)
Hypothyroid 2-4 years (n=11)	9 (81.81)	2 (18.18)
Hypothyroid ≥ 5 years (n=2)	1 (50.00)	1 (50.00)
Acute pain (n=5)	2 (40.00)	3 (60.00)
Chronic pain (n=38)	12 (31.57)	26 (68.42)

PSQI score >5 indicates poor sleep quality. Subtype total comparison (hyperthyroid vs hypothyroid, Table 2) is the only formally tested contrast in this table; duration and pain-duration strata are descriptive.

Table 5 Psychological distress (DASS-42, combined highest-subscale severity rating) and irritability

Thyroid state and duration	Normal n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Irritable n (%)
Hyperthyroid ≤ 1 year (n=6)	1 (16.66)	2 (33.33)	3 (50.00)	-	5 (83.33)
Hyperthyroid 2-4 years (n=11)	1 (9.09)	3 (27.27)	6 (54.54)	1 (9.09)	8 (72.72)
Hyperthyroid ≥ 5 years (n=6)	1 (16.66)	2 (33.33)	2 (33.33)	1 (16.66)	4 (66.66)
Hypothyroid ≤ 1 year (n=7)	1 (14.28)	1 (14.28)	4 (57.14)	1 (14.28)	4 (57.14)
Hypothyroid 2-4 years (n=11)	2 (18.18)	2 (18.18)	7 (63.63)	-	9 (81.81)
Hypothyroid ≥ 5 years (n=2)	1 (50.00)	-	1 (50.00)	-	2 (100.00)
Acute pain (n=5)	2 (40.00)	1 (20.00)	2 (40.00)	-	4 (80.00)
Chronic pain (n=38)	11 (28.94)	9 (23.68)	16 (42.10)	2 (5.26)	36 (94.73)

DASS-42 = Depression Anxiety Stress Scales-42. Irritability assessed using a validated Irritability Scale. Subtype-level formal comparisons in Table 2; duration and pain-duration strata are descriptive.

this is unlikely to be a chance finding, but the association should be regarded as a nominally significant, hypothesis-generating observation rather than a multiplicity-adjusted, statistically robust one given the modest sample size.

Psychological morbidity and irritability

Table 5 indicates that moderate psychological distress was the most frequent finding on the DASS-42 across both thyroid groups, using the combined highest-subscale severity rating described in Methods. Among hyperthyroid participants, about half reported moderate levels of the combined depression, anxiety, and stress rating; a similar pattern was observed in hypothyroid participants, with 63.63% reporting moderate distress at 2 to 4 years. Irritability was highly prevalent in both subtypes (73.9% hyperthyroid, 75.0% hypothyroid overall) and, descriptively, especially high among participants with chronic pain (94.73%). As shown in Table 2, neither moderate/severe psychological distress ($p=0.756$; OR 0.70, 95% CI 0.20-2.41) nor irritability ($p=1.000$; OR 0.94, 95% CI 0.24-3.74) differed significantly by thyroid subtype when formally tested; the near-identical irritability rates between subtypes (73.9% vs 75.0%) indicate that irritability screening is warranted across both thyroid subtypes rather than being prioritised for one over the other.

Kinesiophobia (Tampa Scale)

Table 6 shows that kinesiophobia prevalence (TSK ≥ 37) was descriptively higher with increasing disease duration in hyperthyroid participants, from 66.66% at ≤ 1 year to 83.33% at ≥ 5 years, and remained consistently high among hypothyroid participants across all durations. Kinesiophobia was descriptively more common in chronic pain (76.31%) than acute pain (60.00%). Overall kinesiophobia prevalence did not differ significantly by thyroid subtype (73.9% vs 75.0%, $p=1.000$; OR 0.94, 95% CI 0.24-3.74, Table 2), indicating that kinesiophobia is a pervasive feature of adhesive capsulitis with co-existing thyroid dysfunction regardless of subtype rather than being subtype-specific.

Functional disability (DASH)

Table 7 demonstrates that moderate disability was the most frequent category in both thyroid groups using the collapsed categorisation defined in Methods (mild <30 , moderate 30-50, severe >50). Descriptively, severe disability was more frequent in hypothyroid participants at longer disease durations. Overall, moderate-to-severe disability did not differ significantly by thyroid subtype (82.6% vs 90.0%, $p=0.669$; OR 0.53, 95% CI 0.09-3.24, Table 2). The descriptive trend toward greater severe

Table 6

Kinesiophobia levels (Tampa Scale for Kinesiophobia, TSK ≥ 37 classified as present)

Thyroid state and duration	Kinesiophobia present n (%)	Kinesiophobia absent n (%)
Hyperthyroid ≤ 1 year (n=6)	4 (66.66)	2 (33.33)
Hyperthyroid 2-4 years (n=11)	8 (72.72)	3 (27.27)
Hyperthyroid ≥ 5 years (n=6)	5 (83.33)	1 (16.66)
Hypothyroid ≤ 1 year (n=7)	4 (57.14)	3 (42.85)
Hypothyroid 2-4 years (n=11)	9 (81.81)	2 (18.18)
Hypothyroid ≥ 5 years (n=2)	2 (100.00)	-
Acute pain (n=5)	3 (60.00)	2 (40.00)
Chronic pain (n=38)	29 (76.31)	9 (23.68)

Subtype-level formal comparison in Table 2; duration and pain-duration strata are descriptive.

Table 7

Upper extremity disability (DASH Scale; mild <30 , moderate 30-50, severe >50)

Thyroid state and duration	Mild n (%)	Moderate n (%)	Severe n (%)
Hyperthyroid ≤ 1 year (n=6)	1 (16.66)	3 (50.00)	2 (33.33)
Hyperthyroid 2-4 years (n=11)	2 (18.18)	6 (54.54)	3 (27.27)
Hyperthyroid ≥ 5 years (n=6)	1 (16.66)	3 (50.00)	2 (33.33)
Hypothyroid ≤ 1 year (n=7)	1 (14.28)	4 (57.14)	2 (28.57)
Hypothyroid 2-4 years (n=11)	1 (9.09)	7 (63.63)	3 (27.27)
Hypothyroid ≥ 5 years (n=2)	-	1 (50.00)	1 (50.00)
Acute pain (n=5)	1 (20.00)	3 (60.00)	1 (20.00)
Chronic pain (n=38)	6 (15.78)	22 (57.89)	10 (26.31)

DASH = Disabilities of the Arm, Shoulder and Hand. Subtype-level formal comparison in Table 2; duration and pain-duration strata are descriptive.

Table 8

Quality of life (SF-36; unhealthy = mean domain score <50)

Thyroid state and duration	Healthy n (%)	Unhealthy n (%)
Hyperthyroid ≤ 1 year (n=6)	5 (83.33)	1 (16.66)
Hyperthyroid 2-4 years (n=11)	8 (72.72)	3 (27.27)
Hyperthyroid ≥ 5 years (n=6)	4 (66.66)	2 (33.33)
Hypothyroid ≤ 1 year (n=7)	5 (71.42)	2 (28.57)
Hypothyroid 2-4 years (n=11)	7 (63.63)	4 (36.36)
Hypothyroid ≥ 5 years (n=2)	1 (50.00)	1 (50.00)
Acute pain (n=5)	4 (80.00)	1 (20.00)
Chronic pain (n=38)	21 (55.26)	17 (44.73)

SF-36 = Short Form-36 quality of life questionnaire. Subtype-level formal comparison in Table 2; duration and pain-duration strata are descriptive.

Table 9

Pain severity (Visual Analogue Scale, severity bands: mild <30 mm, moderate 30-54 mm, severe ≥ 55 mm)

Thyroid state and duration	Moderate n (%)	Severe n (%)
Hyperthyroid ≤ 1 year (n=6)	5 (83.33)	1 (16.66)
Hyperthyroid 2-4 years (n=11)	9 (81.81)	2 (18.18)
Hyperthyroid ≥ 5 years (n=6)	4 (66.66)	2 (33.33)
Hypothyroid ≤ 1 year (n=7)	5 (71.42)	2 (28.57)
Hypothyroid 2-4 years (n=11)	8 (72.72)	3 (27.27)
Hypothyroid ≥ 5 years (n=2)	1 (50.00)	1 (50.00)
Acute pain (n=5)	3 (60.00)	2 (40.00)
Chronic pain (n=38)	27 (71.05)	11 (28.94)

VAS = Visual Analogue Scale. Subtype-level formal comparison in Table 2; duration and pain-duration strata are descriptive.

disability among hypothyroid participants with longer duration is consistent with the cumulative structural and functional impact of thyroid-related periarticular pathology and prolonged shoulder immobility, but should be confirmed in a larger sample, with a wide confidence interval consistent with both a true absence of subtype difference and a moderate undetected effect, before being treated as an established subtype difference.

Quality of life (SF-36)

Table 8 shows that the proportion classified as unhealthy (mean SF-36 domain score below 50, as defined in Methods) increased descriptively with longer disease duration in both groups: among hyperthyroid participants, from 16.66% at ≤ 1 year to 33.33% at ≥ 5 years, and among hypothyroid participants, from 28.57% to 50.00%. Overall unhealthy classification did not differ significantly by thyroid subtype (26.1% vs 35.0%, $p=0.740$; OR 0.66, 95% CI 0.18-2.42, Table 2). Poor quality of life was descriptively more common in chronic pain (44.73%) than acute pain (20.00%). These patterns suggest that cumulative burden of pain, functional limitation, and psychological distress, rather than thyroid subtype alone, may primarily drive quality-of-life impairment in this population.

Pain severity (VAS)

Table 9 shows that all participants reported moderate to severe pain (VAS ≥ 30 mm), with no mild pain recorded. Severe pain was descriptively more frequent in hyperthyroid participants at ≤ 1 year and 2 to 4 years durations than in hypothyroid participants at the same durations, though overall severe pain prevalence did not differ significantly by thyroid subtype (21.7% vs 30.0%, $p=0.728$; OR 0.65, 95% CI 0.16-2.57, Table 2). Chronic pain cases had a descriptively similar proportion of severe pain (28.94%) to acute pain cases (40.00%).

Discussion

This study provides, to our knowledge, among the first within-cohort characterisations of eight physical, psychological, and functional domains of burden in Indian patients with AC co-existing with thyroid dysfunction, stratified by both thyroid subtype and disease duration, and among the first to formally test the association between thyroid subtype and each domain, with accompanying effect sizes and confidence intervals, rather than relying on descriptive percentage comparison alone. This distinction matters: of the eight domains tested, only sleep quality showed a statistically significant association with thyroid subtype under the conventional threshold, but this association did not remain significant after Bonferroni correction for multiple comparisons and is therefore reported as a nominally significant, hypothesis-generating finding. This finding, rather than a broad claim that hyperthyroid patients fare worse across all measured domains, is the principal exploratory contribution of this study, to be confirmed in a larger, adequately powered cohort.

Sleep quality

Poor sleep quality was significantly more common among hyperthyroid than hypothyroid participants (69.5% vs 30.0%, $p=0.015$; OR 5.33, 95% CI 1.45-19.67). This is mechanistically consistent with the stimulatory effects of hyperthyroidism on the central nervous system, including adrenergic activation, tachycardia, and thermoregulatory disruption, which would be expected to produce more pronounced sleep disturbance than the metabolically suppressive state of hypothyroidism [9-13]. This subtype-specific pattern, visible only because sleep quality was measured in the same cohort as the other seven domains

and formally tested with an accompanying effect-size estimate rather than only described, identifies hyperthyroid-related AC patients as a subgroup for whom proactive sleep screening may be considered as part of AC physiotherapy assessment, an addition not part of standard practice, pending confirmation in an adequately powered study. This is the one finding in this study for which the point estimate and confidence interval are most suggestive of a genuine subtype difference rather than a purely descriptive observation, but it should be interpreted as nominally significant and hypothesis-generating, since it does not survive Bonferroni correction for the eight comparisons tested, and no single primary outcome was pre-specified for this study.

Physical activity, psychological morbidity, kinesiophobia, functional disability, quality of life, pain, and irritability

For the remaining seven domains, no statistically significant association with thyroid subtype was detected, and the corresponding confidence intervals were wide, so a true subtype difference of moderate magnitude cannot be excluded on the basis of this study alone. Physical inactivity was near-universal across both subtypes and all disease durations, with no participant achieving health-enhancing activity levels; this uniformity, rather than a subtype-specific pattern, indicates that graded activity rehabilitation may reasonably be considered a default component of thyroid-AC physiotherapy for all patients, pending confirmation of its effectiveness in interventional studies [14]. Psychological distress and irritability were similarly prevalent in both subtypes [15-17], supporting consideration of routine psychological and irritability screening across all patients with adhesive capsulitis and co-existing thyroid dysfunction rather than selective screening by subtype. Kinesiophobia was pervasive and, descriptively, increased with disease duration in hyperthyroid participants; because fear of movement is likely to impede physiotherapy rehabilitation by promoting activity avoidance and perpetuating shoulder stiffness, cognitive-behavioural graded exposure and pain neuroscience education may be considered regardless of subtype, and their effectiveness in this population should be evaluated in future interventional studies [18]. The descriptive trend toward greater functional disability among hypothyroid participants with longer disease duration is consistent with the cumulative structural and functional impact of thyroid-related periarthral pathology and prolonged immobility [19], but did not reach statistical significance in this sample ($p=0.669$; OR 0.53, 95% CI 0.09-3.24) and should be regarded as hypothesis-generating pending confirmation in a larger cohort [20]. Quality of life impairment increased descriptively with disease duration in both subtypes, consistent with a picture in which cumulative pain, functional limitation, and psychological distress, rather than thyroid subtype alone, primarily drive quality-of-life burden [21-24]. Descriptively higher rates of severe pain among hyperthyroid participants are consistent with proposed effects of hyperthyroidism on pain sensitisation through central adrenergic and serotonergic pathways, but this difference also did not reach statistical significance ($p=0.728$; OR 0.65, 95% CI 0.16-2.57) and warrants confirmation before being treated as an established subtype distinction.

Interpreting non-significant findings

It is important to note that a non-significant result in this study does not establish the absence of a true difference between thyroid subtypes. A post hoc power appraisal indicates that,

with subtype group sizes of 23 and 20, this study had limited power to detect anything short of a large effect: for a two-sided Fisher's exact test at $\alpha=0.05$, the achieved power to detect a 25-percentage-point absolute difference between subtypes was approximately 45 to 55% depending on the baseline rate, meaning a true moderate difference in domains such as pain severity or functional disability had a substantial chance of being missed. The descriptive percentage differences reported throughout this Discussion for non-significant domains are presented as hypothesis-generating observations warranting testing in a larger, adequately powered cohort, not as findings this study has established.

Limitations

This study has several limitations. The cross-sectional design, in which all outcomes were assessed at a single visit, limits causal interpretation and precludes assessment of within-patient change over time; the duration-stratified comparisons in this manuscript should be read as cross-sectional differences between patients at different points in their disease course, not as a longitudinal trajectory. The single-centre setting and convenience sampling may reduce generalisability. The sample size, while sufficient to formally test subtype-level associations collapsed across duration, was too small to permit reliable inferential testing of duration-stratified or pain-duration subgroups, several of which contained as few as 2 to 6 participants; these strata are reported descriptively only and should not be interpreted as statistically confirmed patterns. No a priori sample-size or power calculation was performed; the post hoc appraisal above indicates this study was adequately powered only to detect large between-subtype differences, and moderate true differences may not have been detected (Type II error risk). The binary "unhealthy" SF-36 classification and the combined highest-subscale DASS-42 "psychological distress" rating are both derived, non-standard summary measures created for this analysis; they do not carry the same evidentiary weight as the validated continuous SF-36 domain scores or the individual DASS-42 subscales, which were not analysed separately, and findings based on these two derived measures should be interpreted with corresponding caution. Laboratory thyroid parameters (TSH, free T3, free T4) were not available for this analysis, so thyroid subtype in this study reflects clinical diagnosis and current treatment rather than biochemical confirmation at the time of assessment, and disease severity within each subtype could not be evaluated. This study did not include a comparison group of patients with adhesive capsulitis without thyroid dysfunction; consequently, it cannot be determined whether the burden reported here is specifically attributable to thyroid dysfunction or reflects the burden expected with adhesive capsulitis more generally, and the Conclusions below are phrased accordingly. Thyroid-subtype classification was unavailable for 3 of the 46 enrolled participants; the overall demographic and clinical profile in Table 1 is reported for all 46 participants, while the subtype-stratified analyses in Tables 2 to 9 are necessarily restricted to the 43 participants with confirmed subtype, a distinction maintained explicitly throughout the Results. Larger, multicentre studies with longitudinal follow-up, adequate power for duration-stratified and pain-duration analyses, biochemical thyroid parameters, and a non-thyroid AC comparison group are needed to confirm and extend these findings.

Conclusion

A substantial multidimensional burden, including physical inactivity, poor sleep, psychological distress, kinesiophobia, functional disability, reduced quality of life, and persistent pain, was observed in this cohort of patients with adhesive capsulitis and co-existing thyroid dysfunction, present across both hyperthyroid and hypothyroid subtypes; in the absence of a non-thyroid AC comparison group, this burden should not be assumed to be specifically attributable to thyroid dysfunction rather than to adhesive capsulitis itself. Of eight domains formally tested, only sleep quality showed a statistically significant association with thyroid subtype under the conventional threshold, with poor sleep more common among hyperthyroid patients (OR 5.33, 95% CI 1.45-19.67); this association did not remain significant after Bonferroni correction for eight comparisons and is therefore best regarded as a nominally significant, hypothesis-generating subtype difference rather than a statistically robust one. Descriptive trends toward greater pain and irritability among hyperthyroid patients and greater functional disability among hypothyroid patients with longer disease duration were observed but did not reach statistical significance and require confirmation in a larger, adequately powered cohort with a non-thyroid AC comparator. These findings support an individualised, multidisciplinary approach that may reasonably include physiotherapy, psychological assessment, activity rehabilitation, and, specifically for hyperthyroid patients, consideration of proactive sleep screening as a hypothesis-generating observation from this small cross-sectional sample rather than an established, statistically robust indication, with the effectiveness of these interventions to be confirmed in future, adequately powered interventional studies.

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