INTRODUCTION

Insomnia symptoms, characterised by difficulty falling and/or staying asleep, is a common but treatable condition with prevalence up to 36% in the general population and 45% in patients with coronary heart disease (CHD) (Frøjd et al., 2021; Ohayon, 2002). Insomnia symptoms are associated with increased risk of hypertension, heart failure (HF), and cardiovascular (CV) disease (CVD) (Laugsand...
predict the risk of HF and CV mortality among asymptomatic specific and sensitive markers of subclinical myocardial injury and Concentrations of cTnI measured with high-sensitivity assays are morbidity and death in the general population.

calculating cTnI, and whether phenotyping by insomnia symptoms are cross-sectionally associated with higher concentrations of cir- study were therefore to investigate whether insomnia symptoms are are generally higher in men, but the association between cTnI and risk of CV mortality is stronger in women, both in the general pop- ulation and in individuals with obstructive sleep apnea (Omland et al., 2015; Roca et al., 2015). cTnI concentrations are generally higher in men, but the association between cTnI and left ventricular dysfunction and increased risk of CVD (Grassi et al., 2009), and these pathophysiological processes are closely associated with higher cardiac troponin concentrations (Omland et al., 2009, 2013; Seliger et al., 2017). Potential mechanisms linking insomnia symptoms to increased CV risk therefore include increased sympathetic nervous system activity and dysregulation of the HPA axis, possibly promoting hypertension and subclinical myocardial injury (Javaheri and Redline 2017).

Cardiac troponin I (cTnI) is an organ-specific marker of myocardial injury and a standard diagnostic tool in the evaluation of acute myocardial infarction (McCarthy et al., 2019). With the introduction of high-sensitivity assays, very low concentrations of cTnI can be measured in patients with subclinical CVD, as well as in large proportions of apparently healthy individuals (Apple & Collinson, 2012; Apple et al., 2012; Seliger et al., 2017). Concentrations of cTnI measured with high-sensitivity assays are specific and sensitive markers of subclinical myocardial injury and predict the risk of HF and CV mortality among asymptomatic individuals and individuals with stable CHD (Everett et al., 2015; Farmakis et al., 2020; Omland et al., 2013). cTnI concentrations are generally higher in men, but the association between cTnI and left ventricular dysfunction and increased risk of CVD mortality is stronger in women, both in the general population and in individuals with obstructive sleep apnea (Omland et al., 2015; Roca et al., 2015). There are currently no published reports on the association between insomnia symptoms and subclinical myocardial injury as assessed by cTnI. We hypothesised that subclinical myocardial injury is a possible link between insomnia symptoms and increased risk of CVD. The aims of the present study were therefore to investigate whether insomnia symptoms are cross-sectionally associated with higher concentrations of circulating cTnI, and whether phenotyping by insomnia symptoms and concentrations of cTnI may enhance risk stratification for CV morbidity and death in the general population.

2 | METHODS

2.1 | Study design and participants

A detailed description of the Trøndelag Health (HUNT) Study, a large prospective population study carried out in the county of Nord-Trøndelag in Norway, has previously been published (Holmen et al., 2003). The second wave of the study (HUNT2) was carried out from August 1995 to June 1997, where 93,898 residents of the county aged ≥ 20 years were invited to participate and 69% (65,237) accepted this invitation. The conduct of the second wave of the study was set up by the HUNT Research Centre and was both a new cross-sectional survey and a follow-up of the first wave (HUNT1) of the study. The participants included in this study were part of a biomarker substudy encompassing four out of 24 municipalities in the county. Blood samples in the sub-study were collected at the same time as the questionnaire data on insomnia symptoms. Participants with missing data on all sleep questionnaires (n = 1,357) and those who had missing cTnI measurements (298) were excluded, leaving 8,398 participants who were included in the present analysis. Participants with missing data on sleep questionnaires were more likely to be younger, male and did not have significantly different cTnI levels compared to those with data on insomnia symptoms (Table S1). A total of 1,476 individuals did not answer all sleep questionnaires and were therefore not included in the analysis for association of cTnI and number of insomnia symptoms.

2.2 | Insomnia symptoms

Participants completed questionnaires concerning health status, medical history, and lifestyle factors. This included three questions regarding insomnia symptoms: “Have you had difficulties falling asleep in the last month?”, with the response options “never, occasionally, often, almost every night”; “During the last month, have you woken up too early and not been able to get back to sleep?”, with the response options “never, occasionally, often, almost every night”; “How often do you suffer from non-restorative sleep?”, with the response options “never, or a few times a year, one to two times per month, about once a week, more than once a week”. Only individuals aged 20–69 years received the last question.

2.3 | Clinical variables

Blood samples were drawn from the participants by trained nurses who also performed a physical examination with a standardised collection of clinical data. The data collection included height, weight, waist and hip circumference, and systolic and diastolic blood pressure. An automated blood pressure device (Dinamap 845 XT, Criticon) was used for all blood pressure measurements. History of CVD was defined as self-reported history of angina, myocardial infarction, and/or stroke. History of diabetes was defined as having a self-reported history of previous and/or current diabetes. The Hospital Anxiety and Depression Scale (HADS) questionnaire was used to screen for symptoms of depression and/or anxiety (Eriksen et al. 2019; Zigmond & Snaith, 1983). The HADS has previously been described to fulfil reliability and validity...
criteria for anxiety and depression screening in the general population (Bjelland et al., 2002).

2.4 | Biochemical analysis

Non-fasting venous blood samples were collected, centrifuged at room temperature and frozen down to −80°C. For cTnI analysis, samples that had previously been thawed, re-frozen in 2008 and stored at −20°C were shipped on dry ice to Akershus University Hospital, Lørenskog, Norway. Samples were centrifuged for 30 min at 3,500 g before analysis with the Abbott Diagnostics Architect STAT High Sensitive Troponin assay (Omland et al., 2013). The cTnI analysis was performed in 2014 (Lyngbakken et al., 2019). The limit of detection for this assay is 1.2 ng/L (range 0–50 000 ng/L), with a coefficient of variation of 10% at a concentration of 3.0 ng/L (Apple & Collinson, 2012). With control material from the producer, a coefficient of variation of 4.1% was found in the high concentration range (1,500 ng/L), 4.4% in the medium concentration range (200 ng/L), and 6.3% in the low concentration range (20 ng/L). All measurements below the detection limit were assigned a value corresponding to 50% of the limit of detection (i.e. 0.6 ng/L). Other biochemical analyses such as concentrations of total cholesterol, high-density lipoprotein cholesterol, triglycerides, and creatinine in serum were measured by routine laboratory methods (Krokstad et al., 2013). Estimated glomerular filtration rate (eGFR) was calculated with the four-variable Modification of Diet in Renal Disease equation (Levey et al., 2009).

2.5 | Endpoints

Data on admissions for HF were obtained from hospital records and defined as primary diagnosis International Classification of Diseases (ICD) codes 428 (ninth revision) or I50 (10th revision). The Cause of Death Registry of Statistics Norway provides the diagnoses stated as the primary cause of death on the death certificate. CV death was defined as the primary cause of death registered as ICD codes 390–459 (ninth revision) or 100-199 (10th revision). All survival data were obtained from the participation date of the second wave through to 31 December 2016.

2.6 | Statistical analysis

Descriptive statistics are reported as absolute numbers with percentages or medians with interquartile range (quartile one to quartile 3 [IQR]). Categorical variables were compared with the chi-square test and continuous variables with the Mann–Whitney U-test. The cTnI measurements were log transformed for further statistical analysis due to their skewed distribution. To assess the association between insomnia symptoms and cTnI, we included each symptom using the original response categories in five different models of linear regression analysis. Individuals who had not responded to all questions regarding insomnia symptoms were not included in the analyses for the association of cTnI and the increasing number of insomnia symptoms. For the prognostic analyses, we created a composite endpoint of CV death or hospitalisation due to HF. Subjects who reported almost nightly problems with either difficulty falling asleep, difficulty maintaining sleep or having non-restorative sleep more than once a week were categorised as having insomnia symptoms (Laugsand et al., 2014). We categorised participants into different phenotypes according to prevalent insomnia symptoms and circulating cTnI concentrations above/below sex-specific cut-offs (≥4 ng/L for women and ≥6 ng/L for men (Sigurdardottir et al., 2018): (a) insomnia symptoms and cTnI below the sex-specific cut-off (reference category), (b) insomnia symptoms and cTnI above the sex-specific cut-off. Cox proportional hazard regression models were generated to test the relationship between insomnia symptoms with or without cTnI ≥4 ng/L or ≥6 ng/L and time to events. Additional Cox proportional hazard regression models were generated for the subgroup of subjects without prevalent insomnia symptoms, comparing subjects with concentrations of cTnI above/below the sex-specific cut-offs. For all the regression models, Model 1 was unadjusted, Model 2 was adjusted for age and sex, Model 3 was adjusted for smoking in addition to Model 2, Model 4 was adjusted for serum cholesterol and eGFR in addition to Model 3, and Model 5 was adjusted for depression and anxiety in addition to Model 4. As prior studies have suggested a stronger association between cardiac troponins and outcome in women (Omland et al., 2015) a test for interaction by sex was performed. However, no significant interaction was observed and no subgroup analyses by sex were conducted. STATA 15.1 (StataCorp LP) was used to conduct the statistical analysis.

2.7 | Ethics approval

All participants provided written informed consent and both the study was approved by the Regional Ethics Committee (REC 2012/859).

3 | RESULTS

3.1 | Participant characteristics

cTnI was measured in 8,398 individuals, 3,784 men and 4,614 women, who had answered questions on difficulty initiating sleep, maintaining sleep and/or having symptoms of non-restorative sleep. Of those, 259 men (7%) and 585 women (15%) reported significant insomnia symptoms, i.e. 844 in total. Participants with insomnia symptoms were more frequently women, current smokers, and had a higher frequency of history of CVD, hypertension, and diabetes. Additionally, participants with insomnia symptoms had higher body mass index (BMI), higher blood pressure, serum lipids, C-reactive protein (CRP), and a higher score on the HADS (Table 1).
3.2 | Insomnia symptoms and cardiac troponins

Participants with insomnia symptoms were more likely to have cTnI concentrations above the sex-specific cut-offs previously associated with increased risk, 4 ng/L for women and 6 ng/L for men (Table 1). Individuals with insomnia symptoms had higher concentrations of cTnI than those without (median [IQR] 3.4 [2.4–5.2] ng/L versus 3.2 [2.2–4.9] ng/L; \( p = .01 \)), but there was no association between insomnia symptoms and cTnI in a linear regression model (\( \beta = 0.06, 95\% \) confidence interval [CI] [−0.01 to 0.12]) (Table 2). We also assessed the associations of cTnI and each individual symptom of insomnia: difficulty initiating sleep, difficulty maintaining sleep, and non-restorative sleep. In unadjusted models, we observed an association between concentrations of cTnI and difficulty falling asleep (\( \beta = 0.18, 95\% \) CI 0.09–0.27; \( p < .001 \)), problems maintaining sleep (\( \beta = 0.33, 95\% \) CI 0.23–0.44; \( p < .001 \)), and non-restorative sleep once a week or more (\( \beta = 0.06, 95\% \) CI 0.00–0.12; \( p = .04 \)). In adjusted models for age and sex, there was no association between concentrations of cTnI and difficulty falling asleep (\( \beta = 0.00; 95\% \) CI [−0.07 to 0.08]), difficulty maintaining sleep (\( \beta = 0.01, 95\% \) CI [−0.08 to 0.10]) or non-restorative sleep (\( \beta = 0.00, 95\% \) CI [−0.05 to 0.05]). There was no significant association between an increasing number of insomnia symptoms and concentrations of cTnI compared with those with no insomnia symptoms in a linear regression analysis (Table 2).

3.3 | Cardiac troponin, insomnia symptoms and CV death

After a median follow-up of 19.6 years, a total of 948 individuals (11.3%) reached the composite endpoint of CV mortality or HF hospitalisation (474 [50.0%] women, Table 3). Subjects with insomnia symptoms were at increased CV risk after adjusting for age and sex (hazard ratio [HR] 1.26, 95% CI 1.06–1.51; \( p = .01 \)), but this association was attenuated in fully adjusted models (HR 1.14, 95% CI 0.89–1.45; \( p = .31 \)). Subjects with insomnia symptoms and higher concentrations of cTnI were at higher risk of HF and CV death.
In adjusted analyses, participants with insomnia symptoms and cTnI over the sex-specific cut-offs were at increased risk of the composite endpoint (HR 1.71, 95% CI 1.04–2.79; \(p = .03\) (Table 4)) compared to participants with insomnia symptoms and low cTnI.

**DISCUSSION**

In a large cohort of subjects from the general population, there was no significant association between the presence of frequent insomnia symptoms and higher cTnI concentrations or increased CV risk in adjusted models. This suggests no independent association between prevalent insomnia symptoms and subclinical myocardial injury quantified by circulating concentrations of cTnI. However, in accordance with previously reported data, we observed that individuals with cTnI above the sex-specific cut-offs had increased CV risk regardless of insomnia symptoms. In individuals with insomnia symptoms, those with higher cTnI concentrations were at a higher CV risk.

### 4.1 Insomnia symptoms and CV risk

Insomnia symptoms have been associated with an increased risk of CVD in a number of epidemiological studies (Ge et al., 2019; Sofi et al., 2014). More recently, genome-wide association studies with Mendelian randomisation have suggested a direct effect of insomnia symptoms on BMI, diabetes Type 2, and coronary artery disease (Jansen et al., 2019; Lane et al. 2019; Larsson &

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**TABLE 2** Associations of cardiac troponin I with a number of insomnia symptoms

| Insomnia symptoms, \(n\) | Model 1 \(\beta\) (95% CI) | Model 2 \(\beta\) (95% CI) | Model 3 \(\beta\) (95% CI) | Model 4 \(\beta\) (95% CI) | Model 5 \(\beta\) (95% CI) |
|--------------------------|----------------|----------------|----------------|----------------|----------------|
| 0 Ref Ref Ref Ref Ref | 0.06 (−0.01, 0.12) | 0.02 (−0.03, 0.08) | 0.03 (−0.04, 0.08) | 0.01 (−0.05, 0.07) | 0.03 (−0.03, 0.10) |
| 1 | 0.02 (−0.08, 0.13) | −0.03 (−0.13, 0.06) | −0.03 (−0.12, 0.06) | −0.02 (−0.11, 0.07) | 0.00 (−0.09, 0.11) |
| 2 | 0.08 (−0.16, 0.31) | −0.03 (−0.24, 0.18) | −0.03 (−0.24, 0.18) | −0.09 (−0.30, 0.12) | −0.03 (−0.26, 0.20) |
| 3 | | | | | |
| \(N\) | 6,922 | 6,922 | 6,872 | 6,862 | 6,022 |
| \(p\) for trend | 0.142 | 0.856 | 0.902 | 0.569 | 0.589 |

Model 1 unadjusted; Model 2, adjusted for age and sex; Model 3, adjusted for age, sex and smoking; Model 4, adjusted for model 3, cholesterol and estimated glomerular filtration rate; Model 5, adjusted for model 4 and depression and anxiety. Being categorised as having an insomnia symptom required difficulty falling asleep and early awakenings to be prevalent almost every night and non-restorative sleep more than once a week. Individuals with three insomnia symptoms therefore answered that they had difficulty falling asleep and maintaining sleep almost every night in addition to having non-restorative sleep more than once a week.

**TABLE 3** Cardiovascular (CV) mortality and heart failure (HF) events according to insomnia symptoms

| Events | No insomnia, \(N\), \(n\) (%) | Insomnia, \(N\), \(n\) (%) | \(p\) |
|--------|-----------------|-----------------|---|
| CV mortality | 7,554 695 (9.2) | 844 116 (13.7) | <.001 |
| HF | 7,554 227 (3.0) | 844 45 (5.3) | <.001 |
| Composite endpoint | 7,554 811 (10.7) | 844 137 (16.2) | <.001 |
| Women | | | |
| CV mortality | 4,029 332 (8.2) | 585 74 (12.6) | <.001 |
| HF | 4,029 113 (2.8) | 585 34 (5.8) | <.001 |
| Composite endpoint | 4,029 384 (9.5) | 585 90 (15.4) | <.001 |
| Men | | | |
| CV mortality | 3,525 363 (10.3) | 259 42 (16.2) | .003 |
| HF | 3,525 114 (3.2) | 259 11 (4.2) | .38 |
| Composite endpoint | 3,525 427 (12.1) | 259 47 (18.1) | .005 |
Despite this, insomnia symptoms are not recognised as an established risk factor for CVD, both due to a lack of understanding of the mechanisms linking insomnia symptoms to CV risk and inconsistencies in previous studies on the association between insomnia symptoms and CVD (Ge et al., 2019; Javaheri and Redline 2017). Insomnia is a state of hyper-arousal and a possible link between insomnia and CVD is an increase in sympathetic nervous system activity (Zhang et al., 2011). Experimental physiological studies in humans have indeed suggested that both insomnia diagnosis and lack of normal sleep is associated with persistent high sympathetic activity and an increase in circulating noradrenaline and adrenaline (Irwin et al., 2003; Redwine et al., 2000; Spiegel et al., 1999). Similar hyperactivity of the sympathetic nervous system is seen in HF, where it might contribute to diffuse myocardial fibrosis, development of left ventricular dysfunction, and increased risk of CVD (Grassi et al., 2009). HF is independently associated with increased concentrations of circulating cTnI (Januzzi et al., 2012).

In the present study, we did not find an independent association between insomnia symptoms and concentrations of cTnI, which suggests that in most cases, insomnia symptoms are not associated with subclinical myocardial injury and subsequent increased risk of HF and CV death. Our present findings did not change after removing the question regarding non-restorative sleep from the analysis and were therefore the same regardless of whether the older or newer guidelines for insomnia symptoms were used. This inference was corroborated by the observation that having insomnia symptoms was associated with a modest and non-significant increase in CV risk in the present population after adjustment for potential confounders. Indeed, individuals with insomnia symptoms had a number of known comorbidities that increase the risk of HF and CV mortality, such as tobacco smoking, higher BMI, and prevalent diabetes and hypertension that could confound the association between insomnia symptoms and CV risk. Individuals with insomnia symptoms and increased cTnI had an increased risk of a composite endpoint in crude analysis (Table 4). In an explorative analysis of the associations between cTnI

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**FIGURE 1** Kaplan–Meier survival curves for the endpoint of cardiovascular mortality or heart failure events according to insomnia symptoms and cardiac troponin I (cTnI) concentrations

**TABLE 4** Associations between cardiac troponin I (cTnI) concentrations and cardiovascular mortality and heart failure events in participants with and without insomnia symptoms

| Participants with insomnia | Participants without insomnia |
|-----------------------------|------------------------------|
| **N**                       | **N**                        |
| Model 1                     | 844                          | 7,554 |
| cTnI ≥4.0 ng/L for women and | 4.23 (2.99, 5.97)*           | 7.75 (6.69, 8.97)* |
| ≥6ng/L for men, HR (95% CI) |                             |       |
| Model 2                     | 844                          | 7,554 |
| 1.49 (1.03, 2.16)*          | 2.09 (1.78, 2.44)*           |
| Model 3                     | 832                          | 7,554 |
| 1.53 (1.04, 2.25)*          | 2.09 (1.78, 2.45)*           |
| Model 4                     | 832                          | 7,554 |
| 1.54 (1.05, 2.26)*          | 2.11 (1.80, 2.48)*           |
| Model 5                     | 615                          | 7,554 |
| 1.71 (1.04, 2.79)*          | 1.95 (1.61, 2.35)*           |

*HR, hazard ratio: Model 1, unadjusted; Model 2, adjusted for age and sex; Model 3, adjusted for age, sex and smoking; Model 4, adjusted for model 3, cholesterol and estimated glomerular filtration rate; Model 5, adjusted for model 4 and depression and anxiety. *p < .05.
and the specific endpoints of CV death, HF hospitalisation and acute myocardial infarction (AMI), the association appeared to be stronger for the endpoint CV mortality than for HF hospitalisation or AMI (Table S2).

Despite a possible causal association of insomnia symptoms on coronary artery disease in a Mendelian randomisation study from the UK biobank, (Lane et al. 2019) a meta-analysis of 29 cohort studies found the association between insomnia symptoms and CV mortality to be non-significant (Ge et al., 2019). Additionally, the meta-analysis found that although insomnia symptoms were not associated with CV mortality (low-to-moderate certainty), difficulty falling asleep and non-restorative sleep were significantly associated with increased CV mortality (Ge et al., 2019). These conflicting observations underscore the heterogeneity of insomnia symptoms and that risk of coronary artery disease may not translate into moderate or high risk of subclinical myocardial injury or CV death. Additionally, inconsistent adjustment for potential confounding factors and variability in measurements of insomnia symptoms further complicate the interpretation of observational studies and meta-analysis based on these. Although insomnia symptoms were not independently associated with increased levels of cTnl, higher levels of cTnl might identify individuals with insomnia symptoms in the general population at a significantly increased risk of HF and CV mortality. Measuring the severity of insomnia symptoms and how they might affect CVD is challenging as the diagnosis of insomnia is based on subjective criteria. Using existing serum biomarkers for subclinical myocardial injury can present a useful objective tool to help sleep clinicians stratify CV risk in their patients with insomnia symptoms.

4.2 | Strengths and limitations

Major strengths of the present study include a substantial sample size, measurement of cTnl with one of the most sensitive assays currently available, and long-term follow-up of clinical endpoints from the HUNT2 study. The main reason for using HUNT2 data was to obtain optimal statistical power. The number of cTnl measurements in HUNT2 was almost twice that of HUNT3; in addition, the follow-up time was almost 10 years longer. HUNT4 was performed in 2018–2019 and to date, follow-up data are not available. However, several important limitations are worth mentioning. First of all, data on the prevalence of insomnia diagnosis, sleep latency, efficiency, sleep stage distributions, sleep disordered breathing, and sleep length were not available for our present cohort, barring us from making further phenotyping based on these characteristics. The main limitation of not having polysomnographic data is that we cannot assert whether any of the study participants fulfilled diagnostic criteria for obstructive sleep apnea. However, polysomnography and/or other objective measurements of sleep are not the standard in the current diagnosis and treatment of insomnia without clinical suspicion of other sleep disorders (Riemann et al., 2017). Second, the sleep questionnaires are subject to recall and response bias. Additionally, the present cross-sectional data did not include follow-up information on the duration of insomnia symptoms, and we were therefore unable to evaluate whether the participants had transient or chronic insomnia symptoms. This limitation may have obscured an association between chronic insomnia and the risk of subclinical myocardial injury and/or CV events.

Insomnia symptoms can vary in prevalence and intensity over time, and menopausal status is related to both risk of disturbed sleep and CV events (Xu & Lang, 2014). It is a limitation of the present study that we could not account for the progression of insomnia symptoms or the effect of menopause on cTnl in women with insomnia symptoms. Another major limitation of the present study is a lack of imaging data to detect subclinical atherosclerosis and/or scarring of myocardial tissue in individuals with increased circulating cTnl. The study cohort is also ethnically homogenous with predominantly Caucasians of North-European descent, limiting generalisability to other ethnic groups.

4.3 | Clinical implications

Insomnia is a common but heterogeneous sleep disorder that is prevalent in both younger and older adults, both with and without objective short sleep duration (Bonnet et al., 2014). Although insomnia symptoms have been associated with adverse CV outcomes, the association with CV risk is modest. Moreover, randomised controlled trials (RCTs) are best suited to control for confounding factors, but there is a lack of RCTs investigating the impact of treatment for insomnia on CV endpoints (Larsson & Markus, 2019). However, a newly published RCT assessed the short-term effect of cognitive behavioural therapy for insomnia (CBT-I) on CV risk factors such as 24-hr ambulatory blood pressure, heart rate, CRP and N-terminal pro-B-type natriuretic peptide (NT-proBNP) in 46 individuals without CVD before and after 8 weeks of CBT-I therapy. The study found no significant treatment effects on these markers of CVD in those receiving treatment or randomised to waitlist control (Johann et al., 2020). That study did not include individuals at increased risk of CVD or elevated cTnl in their analysis, but reaches the same conclusion as a previous study published in 2017 that CBT-I did not lower blood pressure in individuals free of known CVD (Mcgrath et al., 2017).

With regard to CV risk prediction, evidence is accumulating for the use of cardiac troponin as an index of CV health (Welsh et al., 2019). In patients with increased serum cholesterol, statin therapy attenuates both CV risk and concentrations of cardiac troponin, with especially strong reductions in CV risk in patients with high baseline concentrations of cardiac troponin (Everett et al., 2015; Ford et al., 2016). A similar approach could be undertaken in individuals with insomnia symptoms, with the reassurance of individuals with insomnia symptoms and low cTnl concentrations and targeted CVD preventive therapy in patients with insomnia symptoms and increased CV risk, as assessed by higher concentrations of cardiac troponin. However, our present findings would first need to be
confirmed by studies that also assess objective sleep measurements and the duration of insomnia symptoms. For individuals with sleep disorders, measurement of cTnI would be especially appealing, as the specificity and sensitivity of cTnI do not seem to be affected by diurnal variations (Wildi et al., 2018). If our present findings are confirmed in other cohorts, cTnI could be a useful tool to evaluate CV risk in individuals with insomnia symptoms. (Farmakis et al., 2020) and help clinicians identify individuals with insomnia symptoms that are at a particularly low risk of developing CVD. Being able to identify individuals with a low risk of CVD in this common but heterogeneous disorder could be a valuable tool to avoid overtreatment and extensive use of clinical resources for CVD risk reduction in a population unlikely to develop HF or CVD. The same resources, testing and targeted therapy could then be focussed on individuals with high CVD risk.

5 | CONCLUSIONS

Although insomnia symptoms were not independently associated with subclinical myocardial injury, cTnI remains a potentially useful CV biomarker in sleep medicine that can stratify individuals with insomnia symptoms into groups at high and low CV risk.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the conception or design of the work. KH contributed to data and analysis tools. Data analysis was performed by FDS and MNL. Figures and tables were prepared by FDS, MNL and TO. All authors interpreted data and contributed to drafting the main manuscript text and revision. All authors approved the final submitted version of this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from HUNT Databank. Restrictions apply to the availability of these data, which were used under license for this study. Data are available at https://www.ntnu.edu/hunt/data by request.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.