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Psychological factors in symptom severity and quality of life in Raynaud's phenomenon

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Abstract

Background: Despite emotional stress being recognised as a key trigger for Raynaud's phenomenon episodes, research in the area is still in its infancy.
Aims: This study investigated the role of psychological factors relating to symptom severity and quality of life, and differences between Raynaud's types (primary and secondary) to further inform the development of intervention in this field.
Method: A cross-sectional design was used. Two hundred and ten adults with Raynaud's completed an online questionnaire measuring stress, anxiety, depression, anxiety sensitivity, beliefs about emotions, symptom severity and quality of life.
Results: Primary and secondary Raynaud's groups differed in anxiety ($p < .004$), symptom severity ($p < .001$) and quality of life ($p < .001$). Stepwise multiple regressions indicated anxiety and Raynaud's type explained 23% variance in hand symptom severity ($p < .001$); anxiety, Raynaud's type and anxiety sensitivity explained 29% variance in symptom severity (global impact, $p < .001$); depression, Raynaud's type and anxiety sensitivity explained 32% variance in quality of life ($p < .001$).
Conclusions: Results highlight the importance of psychological factors in Raynaud's phenomenon, indicating possible targets for treatment. Interventions such as cognitive behavioural therapy, which target both physical and psychological wellbeing, bear some promise as an adjuvant therapy for this group.

Keywords: Anxiety; Beliefs; Depression; Quality of life; Raynaud's phenomenon; Symptoms

Introduction

Raynaud's phenomenon is an intrusive condition that causes vasospastic episodes in the extremities, usually in response to cold, sudden temperature changes or emotional stress, which can induce pain and paraesthesia, compromising hand function (Shapiro and Wigley, 2017). The condition is either primary and idiopathic, or secondary to an underlying condition, such as scleroderma where more than 95% patients have Raynaud's (Meier *et al.*, 2012). Primary Raynaud's affects approximately 5% of the general population, although rates vary by country and population (Garner *et al.*, 2015).

Although most Raynaud's episodes are precipitated by cold exposure, studies have shown that emotional stress triggered approximately a third of episodes and that thematically relevant stressors (e.g. losing gloves in a snowstorm) are particularly important (Freedman and Ianni, 1983; Freedman and Ianni, 1985; Hughes *et al.*, 2015). Raynaud hypothesised that this response is due to over-activity of the sympathetic nervous system in Raynaud's patients, which exaggerates vasoconstriction via the release of norepinephrine (Fardoun *et al.*, 2016; Freedman and Ianni, 1983). An inability to habituate to stressful stimuli has been alternatively suggested to explain

repeated excessive vasoconstriction in Raynaud's patients (Edwards *et al.*, 1998). Affective factors can trigger or exacerbate symptoms in other episodic and inflammatory conditions, demonstrating the interaction between psychological and physical functioning (Harth and Nielson, 2019; Marmura, 2018).

The National Institute for Health and Care Excellence (NICE) recommend reducing stress and retaining warmth if this is a trigger as a first-line management of the condition, but there are currently no interventions in line with these recommendations or other lifestyle recommendations (Daniels *et al.*, 2018; National Institute for Health and Care Excellence, 2022). A systematic review by Daniels and colleagues (2018), which examined the efficacy of behaviour change interventions, concluded that there was not currently enough evidence to support or refute behaviour change interventions in Raynaud's due to low quality studies, but posited that there remained a strong case to further a psychological understanding of the condition, which could provide targets for intervention.

Evidence-based non-pharmacological interventions may provide a more acceptable alternative to pharmacological treatments which are commonly ineffective or cause adverse side effects, such as headaches, dizziness and oedema (Choi and Henkin, 2021).

However, prior to the development of such an intervention there is a need to operationally define the terms used to describe triggers of an episode, 'emotional stress' being the most commonly used in the literature, and suggests a combination of anxiety and stress, which are also used interchangeably in the field. Stress can be characterised as a 'response' to pressure caused by an *external* trigger, whereas anxiety is more of a persistent, excessive worry that remains even without the stressor being present (American Psychological Association, 2019). Brown *et al.* (2001) investigated both constructs and concluded that anxiety, rather than stress, predicted frequency and severity of attacks. The term 'emotional distress' is also used, which more broadly includes depression (Evers *et al.*, 2011; Newton *et al.*, 2012). Depression is common across many physical health conditions and often associated with poorer outcomes (Daré *et al.*, 2019); depressed patients may have lower treatment adherence and be less likely to take care of themselves by keeping warm or less willing to seek help for symptoms, thereby increasing symptom severity (DiMatteo *et al.*, 2000). The non-specificity in the literature creates confusion and resolving this is likely to be pivotal in the development of appropriate non-pharmacological interventions for this group, where there are currently none.

As found in other medical conditions, Raynaud's symptoms have a detrimental influence on quality of life, with impact on everyday activities and the requirement of adjustment and adaptation (Murphy *et al.*, 2021; Pauling *et al.*, 2018). However, current research has not gone beyond simply showing that Raynaud's patients have poorer quality of life than healthy individuals, and that quality of life is lower in secondary Raynaud's compared with primary (De Angelis *et al.*, 2008; Fábián *et al.*, 2019), the latter of which may be attributed to the absence of underlying pathology and lesser severity in primary Raynaud's (Shapiro and Wigley, 2017). Further research is needed to address this knowledge gap; improving quality of life is considered at least as important as treating symptoms (Shapiro and Wigley, 2017).

There has been a growing interest in the psychophysiology literature about the role of anxiety-related constructs in health conditions. Anxiety sensitivity, the fear of anxiety symptoms (physical and emotional) and believing they may cause illness, harm or embarrassment, is one such construct (Horenstein *et al.*, 2018). Anxiety sensitivity may be particularly relevant to Raynaud's patients due to the symptomatic presentation (tingling, numbness) and visible nature of the symptoms (triphasic colours). An overlapping yet distinct construct with anxiety, anxiety sensitivity has been independently associated with symptomology and quality of life in other conditions (Asmundson *et al.*, 2000; Smitherman *et al.*, 2014). Anxiety sensitivity has also been reported to affect quality of life by perpetuating anxiety, depression and avoidance of physical and mental health-promoting activities (Bernstein *et al.*, 2019; Ouimet *et al.*, 2016); anxiety sensitivity may inadvertently increase symptom severity and worsen quality of life through increased fear and avoidance.

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Understandable fear of anxiety may give rise to negative beliefs about experiencing and expressing emotions, a factor reported to be associated with adverse health outcomes (Bowers and Wroe, 2016; Brooks *et al.*, 2017). Consistent with this hypothesis, a qualitative study reported that patients with scleroderma, most of whom have Raynaud's, reported coping with distress by actively suppressing upsetting thoughts and feelings and were reluctant to seek support (Newton *et al.*, 2012). These avoidant strategies are likely to result in reduced social support and helpful coping strategies, serving to induce or maintain low mood (Bowers and Wroe, 2016; Ouimet *et al.*, 2016).

Biopsychosocial models, which explain conditions as a complex interplay between biological, psychological and social factors as seen in Raynaud's, have been increasingly used to explain symptomology in physical health problems and promote a multi-disciplinary approach to treatment (Geenen and Dures, 2019; Miaskowski *et al.*, 2020). Efficacious and acceptable interventions in behavioural medicine which draw on this model, such as cognitive behavioural therapy, are well placed to be adapted for use in this group. Based on the notion that thoughts, feelings, behaviour and physiology are interlinked, evidence supports use in similar conditions such as inflammatory arthritis (Marques *et al.*, 2021). Such an integrated approach has the potential to improve care by broadening intervention options and optimising efficacy of treatment (Daniels and Turner-Cobb, 2017).

The study seeks to address gaps in the literature that could inform future treatment development; specifically, the relative impact of psychological factors on symptom severity and quality of life in Raynaud's phenomenon, with a view to identify possible targets for intervention.

Method

Participants and procedure

Cross-sectional online questionnaire data were collected from adults with Raynaud's using Qualtrics software, recruited via snowballing techniques on social media and two associated charities (Scleroderma & Raynaud's UK and Raynaud's Association). Inclusion criteria stipulated only adults (18+) with either primary or secondary Raynaud's (self-identified) be included in the study sample. After reading the information sheet, participants completed an informed consent form before moving on to the questionnaires battery. Participants could withdraw by exiting the survey before the end. Data were collected between 9 June and 7 July 2020, early on in the Coronavirus infectious disease (COVID-19) pandemic. Sampling took place over a limited 4-week period to ensure stability of the relative temperature and weather.

Of the 269 who participated, 59 participants were removed due to incomplete data or failing to meet age inclusion criteria, leaving a final sample of 210 ($n = 92$ primary; $n = 101$ secondary Raynaud's). Average time since diagnosis was 18.35 years ($SD = 14.60$) and mean age was 47 years ($SD = 13.63$). The sample was mostly female (94.3%), white (94.8%) and either married or partnered (71.4%), with 55.2% having an education level of Bachelor's degree or higher, and only 6.2% were current smokers.

Measures

Independent variables

The 21-item Depression, Anxiety and Stress Scales (DASS-21; Lovibond and Lovibond, 1995) contains three 7-item subscales measuring depression, anxiety and stress. Participants rate how much each statement (e.g. *I found it hard to wind down*) applied to them over the previous week and relevant item scores (0–3) are summed and multiplied by two to calculate subscale scores. The developers have recommended cut-off scores for 'normal', 'mild', 'moderate', 'severe' and 'very severe' that correspond to each subscale (Lovibond and Lovibond, 1995). Internal consistency was

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good or acceptable for stress (α = .88), anxiety (α = .71) and depression (α = .92) subscales in the current study. The total scale and subscales have been validated (Antony *et al.*, 1998).

The 16-item Anxiety Sensitivity Index (Reiss *et al.*, 1986) measures anxiety sensitivity. Participants responded to items such as '*Unusual body sensations scare me*' using a 5-point Likert scale (0 = 'very little' to 4 = 'very much'). Item scores can be summed to produce a total score. Scale items were internally consistent here (α = .91) and validity has been established (Peterson and Plehn, 1999).

The 12-item Beliefs about Emotions Scale (Rimes and Chalder, 2010) measures beliefs about the unacceptability of experiencing and expressing emotions, with items such as '*I should be able to control my emotions*'. Participants respond using a 7-point Likert scale (6 = 'totally agree' to 0 = 'totally disagree'). The scale showed strong internal consistency within this sample (α = .93) and has good validity (Rimes and Chalder, 2010).

Dependent variables

Due to the lack of suitable outcome measures for this group (Daniels *et al.*, 2018), it was necessary to use two symptom severity measures to assess specific and global aspects, a method used in other measures, such as the EQ-5D (EuroQol, 2017). The questionnaires battery consisted of measures with low overall item totals, making it convenient for participants who may tire from completing larger, more time-consuming batteries, especially within clinical samples (Waltz *et al.*, 1991).

The Symptom Burden Index-Hands (Kallen *et al.*, 2010) was used to measure symptom severity (hand function). It is a 5-item subscale of a 40-item measure of symptom burden in systemic sclerosis, a closely related condition. For this study, participants were asked to consider symptoms relating to Raynaud's (Pauling *et al.*, 2018) over the last two weeks and responded to items (e.g. *How often were hands a problem?*) using a rating scale (0–10). The subscale showed excellent internal consistency in this study (α = .98), while the complete index has been validated in systemic sclerosis patients (Kallen *et al.*, 2010).

The Bath Ankylosing Spondylitis Patient Global Score (Jones *et al.*, 1996) was used to measure symptom severity (global impact). Two VAS items (0–10) that ask participants to indicate the effect their disease has had on their wellbeing over the last week and last 6 months are averaged to provide the global score. The two items were highly correlated ($r = .77, p < .001$) and the measure has been previously validated (Jones *et al.*, 1996).

The ONS4-Life Satisfaction (Tinkler and Hicks, 2011) is a validated single-item measure of personal wellbeing asking '*Overall, how satisfied are you with your life nowadays?*' (0–10). As wellbeing is comparable to quality of life, the measure was considered suitable given the lack of relevant measures for this group (Camfield and Skevington, 2008). It is included in the Office for National Statistics (ONS) Annual Population Survey to estimate personal wellbeing in the UK, demonstrating its utility as a wellbeing measure (Office for National Statistics, 2018). The single-item measure also allows for direct measurement of personal wellbeing, reflecting good face validity (Wanous *et al.*, 1997).

Analytic strategy

Total (sub)scale scores were computed in SPSS, version 26. Missing data were replaced with the series mean, as was suitable given the sizable sample and low rate of missing data (1.5%) that were missing completely at random, as determined using Little's MCAR test (Parent, 2012). Cronbach's alpha coefficient was calculated to assess the internal consistency of each scale.

Descriptive statistics were calculated for the total sample, as well as primary and secondary Raynaud's separately, for stress, anxiety, depression, anxiety sensitivity, beliefs about emotions, symptom severity (hand function), symptom severity (global impact) and quality of life, as were

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the proportion within each DASS-21 subscale severity label. Summary data *t*-tests were calculated to make comparisons with previous normative/non-clinical data.

Bivariate correlations (Pearson's *r*) assessed the relationship between stress, anxiety, depression, anxiety sensitivity, beliefs about emotions, symptom severity (hand function), symptom severity (global impact) and quality of life. Concern for multi-collinearity was considered using a threshold of $r > .8$ (Field, 2013).

Two-tailed independent samples *t*-tests were performed to assess group differences between primary and secondary Raynaud's in stress, anxiety, depression, anxiety sensitivity, beliefs about emotions, symptom severity (hand function), symptom severity (global impact) and quality of life. Welch's *t*-test was reported where appropriate as indicated by Levern's test for violations in equality of variances assumption. To account for non-normal distribution of (sub)scale scores, 95% percentile bootstrapped confidence intervals (2000 resamples) were calculated for *t*-tests (Field, 2013). As Raynaud's type could not be inferred from participants who did not specify this, 17 cases were excluded from these analyses.

Stepwise multiple regressions were conducted separately on symptom severity (hand function), symptom severity (global impact) and quality of life to assess the R^2 variance accounted for by stress, anxiety, depression, anxiety sensitivity and beliefs about emotions. Based on prior research, Raynaud's type, condition duration, age, gender and smoking history were controlled for in each regression to account for confounding (Garner *et al.*, 2015). Violations of linearity, normality and homoscedasticity were judged through visual inspection of histograms and scatterplots of the residuals and models were checked for influential outliers (standardised residuals ±3 and Cook's distance >1) and multi-collinearity (tolerance < .01). An alpha level of .05 was used for analyses.

Results

Descriptive statistics for variables and participant proportions within each DASS-21 severity label category are presented in Table 1. In comparison with normative data (Crawford and Henry, 2003; Peterson and Plehn, 1999), participants had significantly higher stress ($t_{251.93} = 7.73$, $p < .001$), anxiety ($t_{236.78} = 10.62$, $p < .001$), depression ($t_{243.10} = 7.46$, $p < .001$) but not anxiety sensitivity ($t_{220.01} = -0.14$, $p = .89$). Participants also had significantly higher negative beliefs about emotions than a previous non-clinical sample (Rimes and Chalder, 2010; $t_{175.36} = 5.01$, $p < .001$).

Bivariate correlations showed that measures of stress, anxiety, depression, anxiety sensitivity, beliefs about emotions, symptom severity and quality of life were all significantly correlated in the expected directions (Table 2). A strong correlation was found between hand function and global impact ($r = .78$, $p < .001$) due to the convergence around symptom severity measurement. Strong correlations were also found between stress and depression ($r = .65$, $p < .001$) and anxiety and anxiety sensitivity ($r = .63$, $p < .001$), indicating the variables were related but below the threshold for possible multi-collinearity, i.e. they are distinct constructs.

Independent samples *t*-tests indicated that participants with primary Raynaud's had significantly lower anxiety ($t_{172.10} = -2.89$, $p = .004$, 95% bootstrapped CI [–4.69, –0.97], $d = .41$), symptom severity in the domain of hand function ($t_{191} = -5.11$, $p < .001$, 95% bootstrapped CI [–2.64, –1.22], $d = .74$) and domain of global impact ($t_{191} = -5.30$, $p < .001$, 95% bootstrapped CI [–2.36, –1.12], $d = .76$) but were higher in relation to quality of life ($t_{188.52} = 3.46$, $p = .001$, 95% bootstrapped CI [0.44, 1.60], $d = .49$) than participants with secondary Raynaud's. The two diagnostic groups did not significantly differ on measures of stress ($t_{191} = -0.23$, $p = .822$, 95% bootstrapped CI [–2.82, 2.07] $d = .03$), depression ($t_{191} = -1.97$, $p = .051$, 95% bootstrapped CI [–4.99, –0.97], $d = .28$), anxiety sensitivity ($t_{184.57} = -1.69$, $p = .092$, 95% bootstrapped CI [–6.13, 0.37], $d = .24$), or beliefs about emotions ($t_{191} = -0.55$, $p = .582$, 95% bootstrapped CI [–5.85, 3.22], $d = .08$).

Stepwise regression analyses indicated that anxiety and Raynaud's type (primary or secondary) explained 23% of the variance in symptom severity (hand function; $R^2 = .23$, $F_{2,207} = 30.50$,

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Table 1. Summary statistics for study variables showing descriptive statistics and participant proportions in Depression, Anxiety and Stress scales severity label categories

Variable	Primary RP (n = 92) M (SD)	Secondary RP (n = 101) M (SD)	Total sample (N = 210) M (SD)	Percentage (%) in each category of Depression, Anxiety and Stress scales total sample (primary RP; secondary RP)				
				Normal	Mild	Moderate	Severe	Very severe
Stress	13.70 (8.69)	13.98 (8.82)	14.20 (8.82)	58.6 (56.5; 64.4)	14.3 (17.4; 10.8)	14.7 (18.5; 10.9)	10.0 (5.4; 11.9)	2.5 (2.2; 2.0)
Anxiety	7.26 (5.05)	10.00 (7.87)	9.08 (7.30)	45.2 (48.9; 44.6)	15.8 (22.8; 10.8)	20.9 (19.6; 21.8)	7.1 (4.4; 8.9)	11.0 (4.3; 13.9)
Depression	8.52 (8.13)	10.95 (8.97)	10.45 (9.17)	51.4 (62.0; 47.5)	19.6 (16.3; 19.8)	18.5 (17.4; 19.8)	3.8 (0.0; 6.0)	6.7 (4.3; 6.9)
Anxiety sensitivity	16.95 (9.75)	19.73 (12.95)	18.89 (12.18)					
Beliefs about emotions	35.87 (14.66)	37.12 (16.64)	36.49 (15.81)					
Symptom severity (hand function)	4.01 (2.59)	5.95 (2.68)	5.12 (2.84)					
Symptom severity (global impact)	4.25 (2.36)	5.99 (2.20)	5.21 (2.49)					
Quality of life	6.53 (1.81)	5.53 (2.23)	5.90 (2.25)					

RP, Raynaud's phenomenon.

Table 2. Bivariate correlations (Pearson's r) for study variables

Variable	Anxiety	Depression	Anxiety sensitivity	Beliefs about emotions	Symptom severity (hand function)	Symptom severity (global impact)	Quality of life
Stress	.51*** (p < .001)	.65*** (p < .001)	.45*** (p < .001)	.20** (p = .004)	.14* (p = .041)	.27*** (p < .001)	−.34*** (p < .001)
Anxiety	—	.57*** (p < .001)	.63*** (p < .001)	.25*** (p < .001)	.40*** (p < .001)	.44*** (p < .001)	−.36*** (p < .001)
Depression		—	.40*** (p < .001)	.21** (p = .002)	.25*** (p < .001)	.33*** (p < .001)	−.54*** (p < .001)
Anxiety sensitivity			—	.47*** (p < .001)	.28*** (p < .001)	.39*** (p < .001)	−.33*** (p < .001)
Beliefs about emotions				—	.15* (p = .033)	.24** (p = .001)	−.20** (p = .004)
Symptom severity (hand function)					—	.78*** (p < .001)	−.15* (p = .026)
Symptom severity (global impact)						—	−.28*** (p < .001)

n = 210. *p < .05; **p < .01; ***p < .001.

Table 3. Stepwise regression for predictors of symptom severity (hand function)

	Model 1			Model 2		
Variable	*B* [95% CI]	SE_B	β	*B* [95% CI]	SE_B	β
Anxiety	0.16 [0.12, 0.20]	.03	.40	0.14 [0.09, 0.18]	.02	.35
Raynaud's type				1.57 [0.85, 2.30]	.37	.27
R^2	.16			.23		
F for change in R^2	39.36***			18.37***		

$n = 210$. CI, confidence interval. ***$p < .001$.

Table 4. Stepwise regression for predictors of symptom severity (global impact)

	Model 1			Model 2			Model 3		
Variable	*B* [95% CI]	SE_B	β	*B* [95% CI]	SE_B	β	*B* [95% CI]	SE_B	β
Anxiety	0.15 [0.11, 0.19]	.02	.44	0.14 [0.10, 0.18]	.02	.40	0.10 [0.04, 0.15]	.03	.28
Raynaud's type				1.37 [0.75, 1.99]	.32	.26	1.37 [0.76, 1.99]	.31	.26
Anxiety sensitivity							0.04 [0.01, 0.07]	.02	.19
R^2	.20			.27			.29		
F for change in R^2	51.11***			18.91***			5.86*		

$n = 210$. CI, confidence interval. *$p < .05$, ***$p < .001$.

Table 5. Stepwise regression for predictors of quality of life

	Model 1			Model 2			Model 3		
Variable	*B* [95% CI]	SE_B	β	*B* [95% CI]	SE_B	β	*B* [95% CI]	SE_B	β
Depression	−0.13 [−0.16, −0.10]	.01	−.54	−0.13 [−0.16, −0.10]	.01	−.52	−0.12 [−0.15, −0.19]	.02	−.47
Raynaud's type				−0.70 [−1.24, −0.16]	.27	−.15	−0.66 [−1.20, −0.13]	.27	−.14
Anxiety sensitivity							−0.02 [−0.05, 0.00]	.02	−.13
R^2	.29			.31			.32		
F for change in R^2	83.88***			6.52*			4.05*		

$n = 210$. CI, confidence interval. *$p < .05$, ***$p < .001$.

$p < .001$); see Table 3. Anxiety accounted for 16% of the variance (b = .40, $p < .001$), while Raynaud's type accounted for an additional R^2 change of 7% (b = .27, $p < .001$). All other entered variables were excluded.

A three-predictor model containing anxiety, Raynaud's type and anxiety sensitivity accounted for 29% of the variance in symptom severity (global impact; $R^2 = .29$, $F_{3,206} = 27.34$, $p < .001$); see Table 4. Anxiety explained 20% of the variance (b = .44, $p < .001$). Raynaud's type contributed an additional R^2 change of 7% (b = .26, $p < .001$) and anxiety sensitivity explained a further R^2 change of 2% (b = .19, $p = .016$). All other entered variables were excluded.

Three significant predictors explained 32% of the variance in quality of life ($R^2 = .32$, $F_{3,206} = 32.68$, $p < .001$); see Table 5. Depression accounted for 29% of the variance (b = –.54, $p < .001$), Raynaud's type explained an additional R^2 change of 2% (b = –.15, $p = .011$), anxiety sensitivity contributed a further R^2 change of 1% (b = –.13, $p = .046$) to the model. All other entered variables were excluded.

The regression models met the necessary assumptions of linearity, normality, and homoscedasticity of the residuals. A single outlier was identified but retained as Cook's

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distance indicated that it was not influential. Tolerance values confirmed absence of multi-collinearity, meaning the regression models were statistically stable and regression coefficients were reliable (Field, 2013). As prior power analysis indicated a sample of 98 was needed to detect a medium effect size observed in prior related work (Ryan and McGuire, 2016; Wan *et al.*, 2016) using $\alpha = .05$, $1 - \beta = .8$, we can confidently report these results.

Discussion

Stress, anxiety and depression were found to be higher in those with Raynaud's when compared with normative data, consistent with a body of research showing that mental health is poorer in people with physical conditions (Crawford and Henry, 2003; Daré *et al.*, 2019). Those with primary and secondary Raynaud's did not significantly differ in terms of stress, depression, anxiety sensitivity or beliefs about emotions, suggesting overall mental health is similar between Raynaud's types; however, anxiety was higher in those who experience Raynaud's secondary to another health problem.

Group differences in relation to symptom severity and quality of life reflect a more significant detrimental impact in secondary Raynaud's in comparison with primary Raynaud's, in keeping with prior research (Fábián *et al.*, 2019; Shapiro and Wigley, 2017). This may be partly attributable to more systemic health problems in those with secondary Raynaud's.

Taken together, these findings suggest that psychological factors and quality of life are integral to functioning and physical health and should be routinely assessed in Raynaud's alongside a primary focus on symptom severity and health status.

Advancement of our understanding regarding the role of psychological factors is reflected in the finding that anxiety, not stress, was independently associated with symptom severity. This suggests that the term anxiety may more accurately describe the 'emotional stress' commonly purported to trigger episodes. This result agrees with previous findings by Brown *et al.* (2001); however, the sample here consisted of both primary and secondary Raynaud's participants rather than just primary Raynaud's. It also provides further support for Raynaud's original sympathetic over-activity hypothesis, which describes a hyperactivity of internal fear-response systems that are associated with anxiety.

Anxiety, known to be amenable to evidence-based therapies such as cognitive behavioural therapy, may provide a target for intervention in Raynaud's. As an intervention which targets emotional wellbeing, quality of life and promotes effective-self management in Raynaud's, cognitive behavioural therapy would be suitably aligned as a potential treatment option, with further modification for this clinical group. It is particularly relevant given the prolific evidence-base for cognitive behavioural therapy as a treatment for anxiety (National Institute of Health Excellence, 2020), which inherently aims to reduce hyperactive sympathetic responses associated with anxiety that are thought to facilitate vasoconstriction in these patients. Given the neurobiological basis behind Raynaud's, it is important that any psychological intervention emphasises these aspects alongside targeting illness-specific beliefs and behaviours which are serving to maintain an overactive sympathetic nervous system (Moseley and Butler, 2015). Employing a multi-disciplinary approach that incorporates input from specialist physiotherapy alongside cognitive behavioural therapy might be especially beneficial to people with Raynaud's.

Anxiety sensitivity accounted for some of the variance (albeit marginal) in quality of life and global impact, but not hand function. This is in line with associations found in related rheumatological conditions (Bernstein *et al.*, 2019; Mehta *et al.*, 2016), of which many will feature Raynaud's. This finding indicates a sensitivity in the physiological response to anxiety and the physiology of their condition in Raynaud's patients, which may impact symptom experience and quality of life. Although highly correlated with anxiety, anxiety sensitivity was independently

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associated with symptom severity, demonstrating that they are indeed distinct constructs and worthy of consideration separately as targets for intervention.

Depression did not predict symptom severity but accounted for a large proportion of the variance in quality of life, which corresponds with associations found in prior related work (Hudson *et al*., 2008; Wan *et al*., 2016). Surprisingly, anxiety was not independently associated with quality of life, contrasting with previous research in related conditions (Anyfanti *et al*., 2016; Sierakowska *et al*., 2019). This does suggest that anxiety does not have as large an impact on quality of life in Raynaud's, compared with depression, which may be partly attributable to the functional and emotional limitations often associated with depression. As such, treating co-morbid depression should also be at the forefront of any intervention as it may work towards improving quality of life in people with Raynaud's.

Beliefs about emotions was not significantly predictive of symptom severity or quality of life in the regression models. This is contrary to findings in other stress-related conditions (Bowers and Wroe, 2016), and inconsistent with theories of emotion in Raynaud's, suggesting that cognitions surrounding the experience of emotion and physiology in Raynaud's may be more complex than in other conditions. A considerable association was exhibited between beliefs about emotions and anxiety sensitivity. Indeed, anxiety sensitivity is a belief about emotion itself and its associated physiology, based in the belief that anxiety symptoms are harmful. Therefore, it is possible the beliefs about emotions that impact symptom severity and quality of life in Raynaud's relate specifically to the experience of anxiety and the knowledge that it can trigger episodes. As such, beliefs about anxiety specifically (i.e. anxiety sensitivity) may be more pertinent to address in this group than beliefs about emotions more generally.

By looking at beliefs about emotions more generally, we may be missing other important condition-related cognitions and belief systems which indirectly maintain symptoms in Raynaud's and give rise to avoidant coping strategies. In their development of the beliefs about sharing illness experiences scale (BASIE), Wroe and Bowers (2019) reported that beliefs regarding the unacceptability of sharing illness experiences maintained cycles of symptoms and distress in fibromyalgia patients. This may be similarly relevant in people with Raynaud's given the common feelings of fear and embarrassment related to the visibility and impact of symptoms which may further serve to trigger or maintain a Raynaud's episode. Raynaud's sufferers with alexithymia who find it difficult identifying and describing feelings may be particularly vulnerable in this regard as having alexithymia may further reduce support-seeking behaviours and increase suppressive emotion regulation strategies (Fabian *et al*., 2020). Further research is needed to understand the complex relationship between beliefs about emotions, expression of emotion and coping strategies in Raynaud's. This may support the development and adaptation of a cognitive behavioural therapy-based treatment model.

The overall findings support a biopsychosocial model for use in Raynaud's; psychological factors have been found to be related to the fear-based activation of the sympathetic nervous system that inhibits blood flow to the extremities, which is likely to be moderated by beliefs that emotional factors are closely related to the activity of their Raynaud's (Newton *et al*., 2012; Pauling *et al*., 2018). Adopting a biopsychosocial lens when assessing, formulating and treating anxiety, anxiety sensitivity and depression in Raynaud's patients is vital due to the interaction between these dimensions in Raynaud's, particularly the autonomic arousal, role of cognition and the social discomfort commonly seen in Raynaud's. While the common approach to the treatment and management of long-term conditions is cognitive behavioural therapy (Daniels, 2021), it would be imperative that the neurobiological components are adequately taken into account within the physiological aspect of this approach.

Study findings also provide empirical support for NICE first-line recommendations that Raynaud's patients minimise their emotional stress to help manage the condition (National Institute of Health Excellence, 2022). Qualitative research reported that those with scleroderma, of whom almost all will have Raynaud's, were reluctant to seek psychosocial support specifically for

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their distress, therefore a stepped care integrated approach may be most suitable to accommodate the different levels of care desired by individuals (Newton *et al.*, 2012). Low-intensity care might include patient education and self-management strategies based on the principles of cognitive behavioural therapy (e.g. non-avoidance of temperate changes/stress), as recommended by NICE for anxiety (National Institute of Health Excellence, 2020).

There are several services available in the UK National Health Service (NHS), as part of an initiative to integrate physical and mental healthcare for people with long-term physical conditions (NHS England, 2018). Talking Therapies in the NHS currently only offer interventions that focus on low mood and anxiety, addressing only part of the care pathway for people with Raynaud's. It would be optimal to offer a more holistic model and approach from which these services can work, focusing on the nervous system through education, formulation to identify relevant beliefs and behaviours, and intervention using cognitive behavioural therapy, as part of a multi-disciplinary approach. Improving Access to Psychological Therapies (IAPT) services co-located in physical health services allow patients to access NICE-recommended therapies alongside physical treatment (NHS England, 2018). This approach promotes greater co-ordination between healthcare providers to comprehensively address the needs of Raynaud's patients and improve overall care but may not be available everywhere.

The findings here could relate to other conditions that are underpinned by similar neurobiological mechanisms (e.g. a sensitised autonomic nervous system) and may also benefit from a multi-disciplinary approach to treatment. Future research in this area is needed to consider the benefits of having a holistic approach to managing conditions such as this where the relationship between physiological and psychological experience are closely bound by the cognitions and neurobiological mechanisms that trigger and maintain them.

Limitations and future research

Due to the cross-sectional design of the study, causal direction cannot be inferred from these results. Prospective longitudinal research is needed to establish a greater understanding of the direction of influence. Nevertheless, the identification of psychological factors that predict variance in symptom severity and quality of life in Raynaud's is important to inform the direction of such research.

It was evident that there is a lack of suitable outcome measures for this group, as reported in Daniels *et al.* (2018), and the online cross-sectional design prohibited the use of the traditional Raynaud's Condition Score diary (Daniels *et al.*, 2018). However, the measures adapted for this study showed good reliability and produced meaningful results that corresponded to measures used in prior Raynaud's studies (Brown *et al.*, 2001; Fábián *et al.*, 2019; Hughes *et al.*, 2015). These should be further tested and considered for use in future research.

Self-selection via online recruitment and self-reporting of Raynaud's type potentially undermined the credibility of the sample. This could have resulted in a biased sample that may not be fully representative, a common challenge in online studies (Gosling and Mason, 2015). Future research would benefit from a clinically confirmed representative sample rather than a self-selected online sample.

Data were collected during a short period in early summertime in the UK, which limited the confounding role of temperature, given its importance in Raynaud's. It would be useful to repeat this study or use a longitudinal design to observe whether the influence of these factors change with the seasons. As data collection took place early on in the COVID–19 pandemic, it is worth noting the potential impact that elevated anxiety and depression experienced during this time may have had in the context of this study, as anxiety is a known trigger for Raynaud's (Gigante *et al.*, 2020; Rettie and Daniels, 2021), although elevated levels of anxiety are unlikely to have altered the nature of the relationships between the key variables.

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Conclusion

These findings provide pivotal insight into the psychological factors associated with symptom severity and quality of life in people with Raynaud's phenomenon, an area that has previously been relatively under-researched despite having a strong theoretical and practical basis for study in this condition. Study results suggest a multi-disciplinary biopsychosocial approach that addresses psychological factors in addition to physical needs may be most appropriate for the treatment of Raynaud's and provide empirical support for NICE first-line recommendations that patients minimise emotional stress to help manage the condition. Cognitive behavioural therapy is suitably aligned as a potential treatment option, considering its recommendations for use with anxiety and robust evidence base supporting its delivery in rheumatological and other medical conditions. This paper presents initial findings that may underpin the adaption of cognitive behavioural therapy for this common, debilitating problem.

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