Use of Thermographic Criteria to Identify Raynaud's Phenomenon in a Population Setting

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ABSTRACT. ***Objective.*** To assess the value of thermographic measurements of digital skin temperature after cold challenge in classifying Raynaud's phenomenon (RP) in a healthy population.

Methods. One hundred seventy-five patients with RP and 404 controls were subjected to a 15°C, 60 s cold challenge test. All participants were women. Digital temperature measurements were taken at baseline, immediately postimmersion, and 10 min after immersion using a portable radiometer.

Results. Baseline skin temperature was a significant predictor of RP; however, the fall in temperature on immersion and the subsequent rewarming rate provided no additional information.

Conclusion. Baseline skin temperature can help to predict the occurrence of RP in patients drawn from the general population, but has relatively low discriminatory power. The cold challenge test itself is of limited additional value for classification. Although objective temperature measurements show little power overall to discriminate between RP and non-RP patients, detecting low baseline digital temperature may be a useful adjunct to clinical history in classifying the disease. (J Rheumatol 2003;30:720–2)

Key Indexing Terms:
THERMOGRAPHY
COLD CHALLENGE TEST
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CLASSIFICATION

Problems of disease definition present an obstacle for objective studies of Raynaud's phenomenon (RP). It is rare to assess patients during an attack; classification is almost always reliant on the patient's recall and is prone to bias. While physiological measurements (including thermography, laser-Doppler flowmetry, and finger systolic blood pressure, alone and in combination with a provocative test such as cold challenge) have shown promise in providing an objective assessment of RP[1-4], all have been assessed in the clinic setting, using patients with either secondary RP or severe and established disease. The use of objective tests has not been examined in a population setting.

We used portable radiometry[5,6] to assess the cold challenge test as an objective measure of RP in a sample from the healthy population.

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MATERIALS AND METHODS

Study participants. These comprised 175 patients classified with RP and 404 controls identified by a questionnaire survey of 3652 women as part of a twin study investigating genetic influence on RP.

Classification of RP. Participants responded to a series of established screening questions: (a) Are your fingers unusually sensitive to the cold? (b) Do your fingers sometimes show unusual color changes? If yes, do they become white, blue, purple, or red?[7]. RP was classified as present if patients reported a history of 2 or more color changes including white, based on accepted criteria[8].

Thermographic assessment. All participants underwent a cold challenge test, which followed a standard protocol[2,6,9]. Hot or caffeinated drinks were avoided on the study day. Participants were lightly clothed with arms bare from the shoulder. Prior to the cold challenge they were exposed to an ambient temperature of 23°C for 15 min. After the equilibration phase, a single trained operator took sequential measurements of all 8 fingertips excluding thumbs, aiming to measure the temperature at the center of the whorl visible on the palmar aspect of the fingertips. This established the baseline skin temperature (B).

The participants' gloved hands were then immersed in a bowl of water at 15°C for 60 s. Immediately after the hands were taken out of the water, the gloves were removed and measurements of the fingertips were taken (Tpost) and again at 10 min postimmersion (T_{10}).

Portable radiometer. Digital temperature measurements were made using a validated[6] Cyclops 330S portable radiometer (Land Instruments, Dronfield, UK).

Statistical analysis. The analysis investigated the discriminatory value of 3 variables in classifying RP: (1) baseline temperature (B); (2) fall (F) (B – Tpost); and (3) rewarm (R) (T_{10} – Tpost). These measurements were derived from the average temperature of all 8 digits at each time point. Logistic regression was used to fit models to the data in which the clinical classification of RP was included as the outcome variable and the temperature measurements (i.e., B, F, and R) as the predictor variables. Age was included as a confounder. The full set of 3 variable, 2 variable, and 1 variable models was examined and their fit compared. All analyses were carried out using Stata[10].

RESULTS

Response characteristics of participants with and without RP. The mean age and the age range of the participants in both groups were similar (Table 1). RP patients had significantly lower baseline temperature and showed a significantly slower rewarming rate compared to non-RP participants.

Logistic regression models (Table 2). The set of models incorporating the baseline temperature variable (i.e., B, BF, and BR models) all showed no significant difference in fit compared to the full 3 variable model (BFR). Conversely, the set of models that did not include the baseline variable (B) (i.e., FR, R, and F models) all showed a significantly worse fit than for the full model. The importance of B is seen in the area under the curve (AUC) values, where there is little difference between the AUC of the B model and the AUC of the full model (BFR). Allowing for the possible confounding effect of age did not affect the results.

Subjects with very low baseline temperatures (≤ 24°C) were nearly 3 times more likely to be RP positive than RP negative (likelihood ratio = 2.89) (Table 3). The cutoff resulted in high specificity (96.0%) but low sensitivity (11.4%) as many patients reporting symptoms of RP did not have particularly cold hands.

Table 1. Characteristics of subjects.

	Raynaud's, n = 175		Non-Raynaud's, n = 404	
	Mean	Range	Mean	Range
Age, yrs	48	32–61	49	32–62
Baseline temp, ˚C	28.30*	20.28–34.99	29.97*	22.04–35.31
Fall, ˚C	6.63	2.29–12.75	6.92	0.33–11.41
Rewarm, ˚C	4.56**	–1.14–12.53	5.29**	–1.59–11.95

*p < 0.01, **p < 0.05.

Table 2. Results of model fitting.

Model	Log Likelihood (LL)	– 2 diff (LL Model–Full BFR Model)	AUC
BFR	–336.41		0.6484
BF	–336.84	0.86	0.6476
BR	–337.96	3.10	0.6441
B	–339.13	5.44	0.6407
FR	–352.18	31.53	0.5671
R	–352.28	31.73	0.5586
F	–353.41	31.99	0.5535

B: baseline variable; F: fall variable; R: rewarm variable.

DISCUSSION

Our results showed that baseline digital temperature can help predict the presence of RP in a population sample, but information derived from the cold challenge procedure is of little additional value. It is most informative at the lower end of the temperature range, where only 4% of controls were found to have baseline hand temperatures below 24°C. All participants with these low finger temperatures had a 3-fold increased likelihood of being classified with RP.

The majority of our patients reporting symptoms of RP did not have particularly cold hands. On its own, therefore, the baseline measure is not a good overall discriminator of RP in population studies. The most valuable contribution of an objective measure of baseline digital temperature for the purposes of classification of RP in a population setting might be to supplement existing clinical criteria.

In this study, we used a clinical definition of RP. When RP has been defined thermographically on the basis of rewarming in the cold challenge, baseline finger temperature alone may be of less predictive value[11]. Our results do not preclude a role for the cold challenge test in other clinic settings, for example in assessing patients with more severe disease or monitoring an individual's response to treatment[12]. However, even in these circumstances, the precise contribution of serial measurements from a cold challenge test has yet to be determined[4].

Our findings highlight an individual's baseline temperature as a stable physiological variable that might provide insight into the etiology of RP. From an epidemiological perspective it would be of interest to compare baseline temperatures in a suitably controlled environment across populations where the prevalence of RP differs. Baseline skin temperature may also prove to be an important phenotype in understanding the genetic basis of RP.

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Table 3. Characteristics of baseline (B) model.

Temperature, ˚C	Sensitivity, %	Specificity, %	Correctly Classified, %	PPV, %	NPV, %	LR+	LR–
< 24	11.43	96.04	70.47	55.56	71.45	2.89	0.92
< 26	27.43	87.87	69.60	49.48	73.65	2.26	0.83
< 28	49.71	70.30	64.08	42.03	76.34	1.67	0.72
< 30	62.86	55.69	57.86	38.06	77.59	1.42	0.67

PPV: positive predictive value; NPV: negative predictive value; LR+: likelihood ratio for a positive test; LR–: likelihood ratio for a negative test.

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