Effect of chilli consumption on postprandial vascular function in humans

7.1 Abstract

Objective: Topical application of chilli causes vasodilation. We investigated the effect of chilli consumption on postprandial vascular function.

Methods: Twenty-six participants aged 48±12 (mean ± SD) years, and BMI 27±4kg/m² consumed 30g/day of a chilli-containing diet (55% cayenne chilli) and bland diet of four weeks each and underwent three meal tests: bland meal after bland diet (BAB), chilli meal after bland diet (CAB) and chilli meal after chilli diet (CAC). Aortic blood pressure, augmentation-index (a measure of arterial stiffness) and subendocardial viability ratio (SEVR; an indicator of myocardial perfusion) were obtained using pulse-wave-analysis, and plasma glucose and serum insulin were measured at fasting to up-to two hours after consumption of the meals.

Results: Area-under-the-curve for serum insulin was lower (p<0.001) and the association effect between meal and BMI (while controlling for insulin and heart rate) demonstrated a higher SEVR (p=0.007) after the CAC meal than the BAB meal.

Conclusion: Regular consumption of chilli may reduce the requirement for postprandial hyperinsulinemia to maintain myocardial perfusion especially in people with increased BMI.
7.2 Introduction

In animal studies, capsaicin, the pungent principle of chilli, dose-dependently acts as a vasodilator, possibly through the increased synthesis of nitric oxide (379, 380). Ingestion of chilli increases the blood flow, especially in the gustatory region (381). Human studies have shown an increase in vasodilatation at the site of applied topical capsaicin. Men respond more readily to topical use of capsaicin compared to women (382).

Responsiveness to increased skin blood flow, with capsaicin ointment has been shown to be higher in younger than in older men (383) and chronic use leads to desensitization (384). To our knowledge, no information is available as to whether oral consumption of chilli induces any effects on the health-related vascular function of adult humans.

Arterial stiffness and reduced coronary perfusion are among the characteristic features of coronary artery disease. A number of techniques, including: pulse pressure, pulse wave velocity, ultrasound, and photoplethysmography are used to detect arterial stiffness. Similarly, myocardial contrast echocardiography, myocardial perfusion scintigraphy, and positron emission tomography are among the techniques used to study myocardial viability. Most of these techniques use invasive methods, or are expensive, non-portable, subjective and observer dependent. Pulse wave analysis (PWA) is a less subjective, non invasive, reproducible and portable technique, used for measuring arterial stiffness (444, 494, 495). PWA employs applanation tonometry to accurately record pressure waves from the radial artery. A validated and generalised reverse transfer function is then used to generate the corresponding aortic arterial waveform (444). From this waveform aortic pressure, augmentation pressure (AG; the pressure difference between the first and second systolic pressure peaks), augmentation index
(AIx; augmentation pressure divided by pulse pressure) and subendocardial viability ratio (SEVR) are calculated (445). Pressure waves are reflected back from the periphery and summated with the forward-going wave to produce the characteristic pressure waveform, the shape of which varies along the vascular tree. With increased vascular stiffness, the pulse wave velocity and the amplitude of the reflective wave is increased and the reflected wave arrives back earlier, leading to higher than first systolic wave and increased central systolic pressure (496, 497). Although PWA does not measure the compliance of the aorta as it is measured by most ultrasound techniques, it has the advantage of measuring the reflecting compliance of the entire vasculature as a whole and is a form of non-invasive measurement of central aortic pressure, which is the pressure actually observed in the left ventricle (498). For example, if there is no change in aortic compliance, the delay in return of the reflected wave will increase left ventricle filling, and hence coronary blood flow (498). If the AG is positive, i.e. the second systolic wave has higher pressure than the first, the drop in AG would also lead to lower central aortic pressure.

We used this PWA technique to study the acute effects on arterial stiffness of different meals with different background diets. The aim of the study was to examine the acute effects of two chilli meals (one after a bland chilli free diet of four weeks and another after eating a diet of four weeks containing chilli) and a bland meal (after three weeks of bland diet), on vascular parameters, using PWA technique.

7.3 Subjects and Methods

This study was a part of research described in Chapter 6, Section 6.3, Page 98. Briefly, on day 22 and day 29 of the bland diet and day 29 of the chilli diet, the postprandial metabolic and vascular responses (including peripheral and aortic blood pressure, HR,
AG, AIx, and SEVR) of the participants were examined for up to 2 hours after the consumption of the three different meals (BAB, CAB and CAC) by fasting subjects. At each time point (fasting, 20, 40, 60, 90 and 120 min after consumption of the meal) brachial blood pressure measurements was obtained with an Omron digital sphygmometer (model T9P, Omron Healthcare Co., Ltd, Illinois, USA) followed by radial artery waveforms (using PWA technique) obtained with a pencil shaped tonometer (SPC-301; Millar Instruments, Houston, USA). Data were collected directly into a computer and processed with a generalised transfer function software (SphygmoCor; AtCor Medical, Sydney, Australia), which allows continuous on-line recording of the radial artery waveform and calculates parameters including HR, Aortic BP, AG, AIx and SEVR. All these measurements (brachial blood pressure and PWA) throughout the study were taken in duplicate, at each time point, at the same site, by a single observer (KDKA).

As I was unable to collect PWA data for each participant, at each time point after the three meals, the analysis was carried out only for those for which data was available for all the time points on all the three meals. Repeated measures ANOVA with GLM, followed by Holm test was used to compare the overall responses (net-AUC) between the three meals. For details on calculations and statistical analysis kindly refer to Chapter 6, Section 6.3. In addition to the net-AUC, vascular data between the three meals was also compared at the individual time points (fasting, 20, 40, 60, 90 and 120 min). Glucose and insulin data (from Chapter 6) of the participants with all vascular results was used to explore the effects of the meals on the associations between the metabolic and vascular responses. These association effects were measured using general linear modelling and z-scores for individual parameters.
7.4 Results

Twenty-six participants, 12 men and 14 women aged 48 ± 12 (mean ± SD) years, with BMI of 27.1 ± 4.3 kg/m² completed the study. Vascular parameters (HR, blood pressure, AG, AIx, SEVR), plasma glucose and serum insulin at the fasting state (time zero) were not significantly before the three meals (Figure 7.1). When compared at individual time points, there was significant heterogeneity in heart rate at 40min (p=0.04) and 90min (p=0.02) after the consumption of the three meals. Heart rate on the chilli meals was lower than the bland meal. SEVR was heterogeneous (p=0.001) at 90min after the meals, with CAC meal exhibiting the highest values and BAB with the lowest values. Glucose at 60min was lower (p=0.04) after the chilli meals than after the bland meal, with the lowest values on the CAB meal. Insulin at 40, 60 and 90min was lower after the chilli meals than the bland meal (all p<0.02) with CAC meal exhibiting the lowest and BAB meal exhibiting the highest insulin concentrations. Although HR, SEVR, glucose and insulin were different at certain time points between the three meals, except for insulin (p<0.001) no significant heterogeneity was observed for other variables when analysed as the net-change (net-AUC from time zero to 120min) after the meals. No significant differences were observed for blood pressure (peripheral and central), AIx and AG between the three meals.

There was a significant positive association between SEVR and each of BMI (p=0.046), and insulin (p<0.001), and negative association with HR (p<0.001) on univariate analysis. Further analysis revealed a heterogeneous association between net-AUC for SEVR and BMI (p = 0.009) on the three meals after controlling for insulin and HR. There was a stronger association (p = 0.007) between SEVR and BMI on the CAC meal (1 s.d. increase in BMI raised the net-AUC for SEVR by 558(% min); confidence-interval -194 to 727 %min compared to the BAB meal where each s.d. increase in BMI
reduced the net-AUC for SEVR by 122 (% min); confidence-interval -661 to 416 % min. There was an intermediate association for the CAB meal between the CAC meal and the BAB meal (p=0.3 for BAB and CAB; and p=0.08 for CAB and CAC).
Figure 7.1 Vascular parameters and serum insulin at fasting to up-to two hours after the consumption of meals.

Fasting values were obtained 30 min prior to eating the meal and assumed to be time zero values; C-SP central systolic pressure, C-DP central diastolic pressure, AIX@HR75 augmentation index corrected for heart rate as 75 bpm (beats per minute); SEVR subendocardial viability ratio; inset for each graph mean ± SEM for net area under the curves; BAB bland meal after bland diet; CAB chilli meal after bland diet; CAC chilli meal after chilli diet. Data are mean ± SEM, n = 26. Inset: net area under the curve (AUC). Analysis by repeated measures ANOVA using the general linear modelling (GLM). All p values for multiple comparisons were adjusted by Holm test; * significant heterogeneity between the three meals at that time point; Bars with different letters are significantly different p < 0.05.
7.5 Discussion

Although no significant differences were observed in any of the vascular parameters (independently) between the three meals, the results of the present investigation suggest that regular chilli consumption (CAC meal) may increase postprandial SEVR (an indicator of myocardial perfusion) when assessing the results while controlling for the changes in insulin and heart rate, especially in people with increased BMI. This result may be relevant to the associations between obesity, metabolic syndrome and CVD.

Previous research has demonstrated that insulin dose dependently increases the myocardial perfusion in lean healthy (97) as well as obese individuals, however the response in the obese is lower (98). For peripheral vasodilation – two to three times more insulin is required in obese than lean individuals to induce similar increase in blood flow (499). As postprandial hyperinsulinemia is an independent risk factor of CVD, the short-term maintenance of blood flow (peripheral or myocardial) at the expense of hyperinsulinemia in obesity may have long-term adverse effects. The results of our study suggest a role for chilli in ameliorating the adverse effects of obesity by reducing the requirement for hyperinsulinemia to maintain myocardial perfusion. Although the exact mechanism of action of chilli is not known, the results are consistent with regular consumption of chilli increasing the hepatic clearance of insulin (476), possibly due to splanchnic vasodilation. This may result in improved insulin sensitivity and utilisation of glucose, not only in the peripheral but also in central tissues leading to reduced insulin resistance and improved effective myocardial perfusion pressure (500). It has also been suggested that plasma glucose is a determinant of myocardial blood flow and reduction in postprandial hyperglycaemia with insulin therapy improves myocardial perfusion in patients with
type 2 diabetes (501). It may be possible that we did not observe a significantly higher SEVR (independently) on the CAC or CAB meals compared to the BAB meal because the postprandial glucose levels were not significantly different between the meals. Further, improved glucose and insulin profile after weight loss has been shown to improve endothelial function in obese humans (502), whereas our study was designed to test the effects of chilli in weight maintenance period.

There were no significant differences at time zero (especially CAB and the CAC meals) for the measured parameters. This suggests that four weeks of chilli diet, compared to the bland diet, did not significantly alter the measured variables in the fasting state. It is important to note that changes in weight, activity levels, and macronutrient composition of the diets, the variables known to alter the measured parameters in this present research, were deliberately kept constant between the two diets. We also acknowledge that SEVR taken as an indicator of myocardial perfusion is assessed using other parameters including heart rate, systolic and diastolic blood pressure etc and not directly, hence it would be difficult to confirm our finding in any direct or practical sense.

Although the results of the present investigation are not conclusive, they are timely, interesting and indicative of a probable beneficial effect of regular chilli consumption on myocardial perfusion. Therefore, further research is warranted with larger sample size probably using different techniques, to examine vascular function in normal, and hyperinsulinemic individuals, as well as those at the high risk of CVD.