

## The effect of increasing fruit and vegetable consumption on overall diet: a systematic review and meta-analysis

S. L. Fulton<sup>1</sup>, C. R. Cardwell<sup>2</sup>, M. C. McKinley<sup>1</sup> and J. V. Woodside<sup>1</sup>

<sup>1</sup>Nutrition and Metabolism Group, Centre for Public Health, Queen's University Belfast, Grosvenor Road, Belfast BT12 6BJ, UK and <sup>2</sup>Cancer Epidemiology and Prevention Research Group, Queen's University Belfast, Grosvenor Road, Belfast BT12 6BJ, UK

WHO recommends consumption of at least five portions of fruit and vegetables per day<sup>(1)</sup>. Evidence suggests high intake of fruit and vegetables is associated with decreased risk of CVD and certain cancers<sup>(2,3)</sup>. It is postulated that increasing fruit and vegetable consumption has direct health benefits; however, increased consumption may also indirectly improve health by changing the overall balance of the diet, as extra fruit and vegetables may be substituted for less healthy foods. It is, therefore, unclear whether the health benefits of fruit and vegetables are directly related to the intrinsic properties of these foods or to their impact on overall diet profile. The aim of the present systematic review and meta-analysis was to determine the effect of increased consumption of fruit and vegetables on overall diet.

Six databases were searched from earliest record until April 2010. Search criteria included fruit and vegetable, randomised controlled trials, adult trials and those published in the English language. A total of 6413 publications were returned on initial search and titles and abstracts reviewed, 173 publications were then retrieved for closer analysis. Of these, twelve papers were included in the final systematic review and seven papers contained sufficient data to form the meta-analysis.

For the purposes of the systematic review, seven of twelve studies reporting on energy in kilojoules and all six studies reporting on protein, showed no significant change when fruit and vegetable consumption was increased. Five of ten studies reporting on total fat, and three of four studies reporting on saturated fat showed significant decreases in intakes, with the remainder reporting no significant change. The two studies measuring monounsaturated fat intake both showed significant decreases. On the other hand, five of seven studies reporting on carbohydrate intake and six of eight studies reporting on fibre intake showed significant increases, while it was also found that the majority of micronutrients (including the carotenoids, lutein, lycopene and vitamins C and E) showed significant increases when fruit and vegetable intake was increased.

For the meta-analysis, having pooled results from seven studies, there was no evidence of a difference in energy in kilojoules between the intervention (i.e. fruit and vegetable group) and control group (mean difference = 37.6 kJ [95% CI -80, 97];  $P = 0.85$ ). In five studies, on average there was a significant decrease in fat, reported as % energy, in the intervention group compared with the control group (mean difference = -4% [95% CI, -5, -3];  $P \leq 0.00001$ ); while in three studies, though not significant, there was also a reduction in fat reported in grams in the intervention group compared with the control (mean difference = -9 g [95% CI -20, 2];  $P = 0.10$ ). Overall, in six studies, on average, fibre in grams was higher in the intervention group compared with the control group (mean difference = 5.36 g [95% CI 4, 7];  $P \leq 0.00001$ ). There was little evidence of heterogeneity in the difference in mean between the intervention and control group, between studies for energy, fat in %, fat in grams or fibre ( $I^2 = 33, 0, 43$  and 27%, respectively).

Therefore, this systematic review and meta-analysis would suggest that, when fruit and vegetable consumption is increased, the overall profile of the diet is improved: micronutrient intakes increase, fat (total expressed as % energy, saturated and monounsaturated) intakes decrease and carbohydrate and fibre intakes increase.

1. World Health Organization (1990) *World Health Organ Tech Rep Ser* 797, 1–160.

2. Dauchet L, Amouyel P, Hercberg S *et al.* (2006) *J Nutr* 136, 2588–2593.

3. World Cancer Research Fund (2002) Expert Report. [http://www.dietandcancerreport.org/downloads/chapters/chapter\\_04.pdf](http://www.dietandcancerreport.org/downloads/chapters/chapter_04.pdf) (accessed March 2011).