In this cohort, an apple a day could keep the doctor away\textsuperscript{1–3}

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A number of issues need resolution in terms of the potential health benefits of dietary fiber, and the article by Buil-Cosiales et al. (1) in this issue of the Journal addresses most of them. Rather than being a study on total fiber intake and risk of one specific disease, Buil-Cosiales et al. have addressed all-cause mortality, parsed out the major causes of that mortality, and included intake of whole grains, fruit, and vegetables in their analyses in addition to total fiber. This study is a hybrid of a randomized controlled trial (RCT)\textsuperscript{4} and an observational study, analyzed (appropriately) as an observational study. Being part of the parent 7447-person RCT provides important additional information such as whether or not increasing fruit or fiber consumption over an \textasciitilde 6-y follow-up has an effect on all-cause mortality. In addition, diet records were taken annually as part of the RCT, and Buil-Cosiales et al. used these repeated measurements of dietary information in their analyses, rather than just having one initial diet assessment at the beginning of a cohort study, or just before and after values for intervention trials. Also of note is that the subjects in this study are elderly and all are at “high risk” of cardiovascular disease (CVD; having hypertension or type 2 diabetes or other risk factors) rather than just having one initial diet assessment at the beginning of a cohort study, or just before and after values for intervention trials. Also of note is that the subjects in this study are elderly and all are at “high risk” of cardiovascular disease (CVD; having hypertension or type 2 diabetes or other risk factors) rather than just having one initial diet assessment at the beginning of a cohort study, or just before and after values for intervention trials. The breadth and novelty of this study, we now address what we can take from it that will help advance our knowledge of fiber intake and health.

\textbf{IS THE FIBER PER SE PROTECTIVE, OR IS IT THE FOODS (e.g., WHOLE GRAINS, FRUIT, AND VEGETABLES) CONTAINING THE FIBER THAT ARE PROTECTIVE?}

After a rather tortuous debate over several decades, The Institute of Medicine of the National Academies (4, 5), Codex Alimentarius (2), and the U.S. Food and Drug Administration (3) have all addressed this issue and come to the same conclusion. If the fiber in fiber-containing foods is in a relatively intact form as found in the original plant, then it is considered “dietary fiber.” Alternatively, if it is synthesized or extracted then put back into a food, there must be substantial scientific validation showing a physiologic benefit to health before it can be counted as fiber. In laymen’s terms, this can be translated into “We’re pretty sure that a fiber-rich diet is a healthy diet (so intact fiber from foods doesn’t have to prove itself), but we’re still unsure as to whether it’s the fiber in the foods or the fact that a plant-based diet high in whole grains, legumes, fruit, and vegetables is a healthy diet. That’s why if fiber is extracted from the plant it does need to prove itself.” One way to shed some light on this issue is to separate out fiber-containing foods from fiber per se and separately evaluate their associations with health outcomes, as was done in this article (1). Buil-Cosiales et al. evaluated the effect of fiber and of different fiber-containing food groups on all-cause mortality. In theory, if the results showed that fiber was more strongly associated with lower all-cause mortality than intake of any of the food sources of fiber, one might conclude that fiber per se rather than intake of the other fiber-containing foods was the key driver of decreased mortality. Unfortunately, results of the study do not provide a clear answer to this question, but they are interesting nonetheless. With regard to baseline data for the independent association of fiber, fruit, vegetable, and whole-grain consumption with all-cause mortality: fiber intake tracked with fruit consumption and both showed a significantly lower total all-cause mortality (\textasciitilde 37% risk reduction with fiber and \textasciitilde 42% risk reduction with fruit consumption). In contrast, neither vegetable intake nor intake of whole grains showed a significant trend toward decreased all-cause mortality. However, if we ask the question “Was the beneficial effect due to fiber intake or intake of a particular food group?” (i.e., fruit), the answer isn’t clear, particularly because the major source of fiber in this study was from fruit.

\textbf{WHAT ARE THE SPECIFIC BENEFICIAL EFFECTS OR EFFECT OF A HIGH-FIBER DIET?}

Although the public and many scientists seem to consider the beneficial effect of a high-fiber diet to be on the colon and colon cancer, the major clinical trials attempting to link intake of a particular fiber, or increasing the amount of total fiber in the diet, have not shown a beneficial effect of fiber intervention on decreased colon polyp recurrence after polyp removal (considered the gold standard for a beneficial effect against colon cancer). Rather, when the Dietary Reference Intake (DRI) Committee on the Macronutrients set intake values for dietary fiber, 1–3 have all addressed this issue and come to the same conclusion. If the fiber in fiber-containing foods is in a relatively intact form as found in the original plant, then it is considered “dietary fiber.” Alternatively, if it is synthesized or extracted then put back into a food, there must be substantial scientific validation showing a physiologic benefit to health before it can be counted as fiber. In laymen’s terms, this can be translated into “We’re pretty sure that a fiber-rich diet is a healthy diet (so intact fiber from foods doesn’t have to prove itself), but we’re still unsure as to whether it’s the fiber in the foods or the fact that a plant-based diet high in whole grains, legumes, fruit, and vegetables is a healthy diet. That’s why if fiber is extracted from the plant it does need to prove itself.” One way to shed some light on this issue is to separate out fiber-containing foods from fiber per se and separately evaluate their associations with health outcomes, as was done in this article (1). Buil-Cosiales et al. evaluated the effect of fiber and of different fiber-containing food groups on all-cause mortality. In theory, if the results showed that fiber was more strongly associated with lower all-cause mortality than intake of any of the food sources of fiber, one might conclude that fiber per se rather than intake of the other fiber-containing foods was the key driver of decreased mortality. Unfortunately, results of the study do not provide a clear answer to this question, but they are interesting nonetheless. With regard to baseline data for the independent association of fiber, fruit, vegetable, and whole-grain consumption with all-cause mortality: fiber intake tracked with fruit consumption and both showed a significantly lower total all-cause mortality (\textasciitilde 37% risk reduction with fiber and \textasciitilde 42% risk reduction with fruit consumption). In contrast, neither vegetable intake nor intake of whole grains showed a significant trend toward decreased all-cause mortality. However, if we ask the question “Was the beneficial effect due to fiber intake or intake of a particular food group?” (i.e., fruit), the answer isn’t clear, particularly because the major source of fiber in this study was from fruit.

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4 Abbreviations used: CVD, cardiovascular disease; DRI, Dietary Reference Intake; RCT, randomized controlled trial.

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the intakes were based on decreased risk of heart disease because this was where the strongest science was (5). The study by Buil-Cosiales et al. (1) is consistent with the DRI value for fiber being based on decreased risk of CVD (5), because they found a significant risk reduction for CVD with both high-fiber diets (54% risk reduction) and fruit consumption (56% reduction). Interestingly, more people in this cohort died of cancer (40% of the total deaths) rather than from CVD (24%), which is of particular note because the investigators purposely selected a population of individuals with a high risk of heart disease.

DOES ONE HAVE TO HAVE A HEALTHY DIET FROM BIRTH OR CAN ONE ADOPT A HIGHER-FIBER DIET LATER IN LIFE AND GET SOME PROTECTION?

This is one of the most interesting findings from the study by Buil-Cosiales et al. (1). They divided the subjects into 1 of 4 categories: 1) participants whose intake was low (lower fifth) in the baseline questionnaire and who did not increase their intake (low/low), 2) participants whose intake was low in the baseline questionnaire and who did increase their intake (low/high), 3) participants who were adequate and remained adequate (high/high), and 4) participants who were initially adequate but who decreased their intake (high/low). They found that if one was in group 2 (low at baseline but increased fiber during the follow-up period), he/she had a lower risk of CVD than did the group who remained with a low intake (1). This is an interesting finding and could lead to other studies on switching to a higher-fiber diet later in life.

ARE THE RESULTS TARGETED ONLY TO “HEALTHY PEOPLE” OR COULD PEOPLE WHO ALREADY HAVE HEART DISEASE BE PROTECTED BY EATING HIGHER-FIBER DIETS?

In most developed countries, dietary guidance, DRI values, and health claims are based on “healthy people,” which tends to encourage investigators to use only healthy people in their trials so that their results can be considered toward establishing DRIs, dietary guidance, or health claims. This is probably one of the most differentiating factors between the current study (1) and others, because the current study focuses on older individuals who are at high risk of contracting CVD, not healthy individuals. It is very clear from the study that these “at risk” individuals still benefit from a diet that is not much higher than the lowest quintile in terms of fiber and fruit intake. And, if they switch from a low-fiber diet to a higher-fiber diet they will benefit in terms of overall mortality.

DOES IT TAKE A MAJOR CHANGE IN DIET TO GET INTO THE PROTECTIVE CATEGORY FOR DECREASED RISK OF ALL-CAUSE MORTALITY?

In the study described (1), the beneficial effect of fiber or fruit on all-cause mortality appears to have a threshold effect in that the biggest gain in benefit of intake of either fiber or fruit on decreased risk of all-cause mortality is between the lowest quintile for fiber or fruit intake and the next quintile (quintile 2). Individuals who had a fiber intake of 17 g/d or 153 g fruit/d (quintile 1; called the reference on which the higher intakes were evaluated) did not have a decreased risk of all-cause mortality, but just moving into the next highest intake level of fiber or fruit produced a benefit of 37–39% decreased risk (see Table 2 in reference 1). The difference in being in quintile 1 and the beneficial quintile 2 for fiber is an extra 4 g (total of 21 g). It is an additional 103 g for fruit. One medium apple (which is the most commonly eaten fruit in this cohort) contains 182 g of fruit and has 4.4 g of fiber, which would mean that adding 1 medium apple to the diet would put an individual from the lowest quintile (not protective) into quintile 2 (the protective category) for both fruit and fiber.

In summary, this interesting article has shed light on a number of issues that are currently being discussed in the fiber/health literature and that need to be investigated in more detail. It shows that certain food sources of fiber (in this case, fruit) may be as protective against all-cause mortality as fiber itself, suggesting that the food source of the fiber is important. It shows that the major effect of a high-fiber diet is on decreased risk of all-cause mortality, and the major contributor to that decrease in mortality is decreased risk of CVD, which is what the DRI value for fiber is based on. It also shows that it is never too late to switch to a higher-fiber diet, and even if one already has a predisposition to heart disease it still will be possible to decrease the risk by having a higher intake of fiber/fruit. Importantly, it would not take a major change in diet to go from no protection of quintile 1 of intake to quintile 2 in which the beneficial effect is observed; the ingestion of 1 medium apple would do this. All of these points require additional studies and verification, but they are indeed encouraging.

JRL is on the Mars Inc. Scientific Advisory Council but found no conflict of interest between that position and this editorial.

REFERENCES