A Randomized, Crossover Trial of High-Carbohydrate Foods in Nursing Home Residents With Alzheimer’s Disease: Associations Among Intervention Response, Body Mass Index, and Behavioral and Cognitive Function

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Background. Despite recognition that weight loss is a problem in elderly persons with probable Alzheimer’s disease (AD), increasing their food intake remains a challenge. To effectively enhance intake, interventions must work with individuals’ changing needs and intake patterns. Previously, the authors reported greater food consumption at breakfast, a high-carbohydrate meal, compared with dinner, and shifts toward carbohydrate preference at dinner in those with increased behavioral difficulties, low body mass index, or both.

Methods. Thirty-four nursing home residents with probable AD who ate independently participated in a randomized, crossover, nonblinded study of two nutrition interventions. The intervention described here included replacing 12 nonconsecutive “traditional” dinners with meals high in carbohydrate but comparable to traditional dinners in protein. Measures included weighed food intake, body weight, cognitive function (as assessed using the Severe Impairment Battery and Global Deterioration Scale), behavioral disturbances (as assessed using the Neuropsychiatric Inventory-Nursing Home Version), and behavioral function (as assessed using the London Psychogeriatric Rating Scale).

Results. Group mean dinner and 24-hour energy intake increased during the intervention phase compared with baseline, protein intake was unaffected, and carbohydrate intake increased. Increased dinner intake, attributable to intervention foods, was achieved in 20 of 32 of participants who completed the study and was associated with increased carbohydrate preference, poorer memory, and increased aberrant motor behavior. Those with low body mass indices were the most resistant to the intervention.

Conclusions. Providing a high-carbohydrate meal for dinner increases food intake in seniors at later stages of the disease who are experiencing cognitive and behavioral difficulties, possibly as a result of a shift in preference for high-carbohydrate foods.

 UNINTENTIONAL weight loss is commonly observed in seniors with probable Alzheimer’s disease (AD) (1–9) and is increasingly likely to occur as the disease progresses (2). Its prevention is a priority because weight loss and low body mass index (BMI) are predictors of morbidity (10), death (2,11), and poor quality of life (12).

Although weight loss is a multifactorial phenomenon in elderly persons (13), specific factors accompanying AD progression, including impaired olfaction (14), increased sweet or carbohydrate preference (15,16), feeding problems (17,18), behavioral and physical difficulties (17,19), and circadian shifts in food intake patterns (19), contribute to altered eating patterns, poor food intake, and low BMIs. To effectively enhance intake, nutrition interventions must work with these changes.

Specifically, we observed that peak food consumption and the highest responsiveness to foods provided both occur at breakfast, the meal highest in carbohydrate (compared with lunch or dinner) (19), in those with increased behavioral difficulties, low BMIs, or both, whereas the poorest intakes occur at dinner (19,20). To focus on the most poorly consumed meal (i.e., dinner) in persons at greatest risk (i.e., those with low BMIs), we evaluated the effect of replacing the “traditional” dinner with a preferred nutrient, carbohydrate (16), on overall food intake in nursing home residents with AD. In addition, we identified participant characteristics, such as carbohydrate preference, BMI, cognitive and behavioral function, and the presence of behavioral problems, that were associated with intervention response.

METHODS

Participants
Residents of the AD units of Baycrest Centre for Geriatric Care’s nursing home (an academic facility associated with the University of Toronto) were eligible for selection. Inclusion criteria were the diagnosis of probable AD made by a qualified clinician and the ability to eat independently.
We used separate power calculations to estimate the number of days of food intake required per resident and the number of participants required. The study was powered

### Study Design

The study was divided into four phases, each lasting 21 days. In phase 1, participants consumed their usual diet, which allowed us to obtain baseline measures. In phase 2, participants were randomly assigned, by unit, to either the high-carbohydrate dinner (HCD) intervention or the mid-morning nutrition supplement intervention [described elsewhere (21)]. Random assignment of the interventions was conducted at the level of the unit, rather than at the level of the resident, to minimize disruptions to the dining room, with 4 of 7 units receiving the HCD intervention first. Participants resumed their usual diet in phase 3, which served as a washout period. In phase 4, participants were assigned the nutrition intervention that they did not receive in phase 2. Participants never received a combination of the two interventions tested. Characteristics of participants receiving the HCD intervention in phase 2 versus phase 4 were not different (Table 1).

All foods served to the participants for all meals, snacks, and the intervention were weighed before consumption, as were any leftover foods, during the entire length of the study, to quantify the amounts consumed. Food consumption was converted to nutrient intake using a software program, Dietary Food Management (DFM Systems, Des Moines, IA), which contains all facility recipes and calculates the nutrient composition based on individual ingredients using the Canadian Nutrient Database (22).

### Dietary Intervention

Knowing a priori that foods served at breakfast are well consumed, we included in the intervention meal several foods habitually served at breakfast. Because of the kosher status of the facility, which precludes serving dairy products and meat at the same meal, the HCD intervention was confined to evenings providing dairy dinners (i.e., 12 intervention dinners per participant). Intervention foods included 1 container of juice, 1 slice of bread with jam, 1 bowl of hot or cold cereal, 1 hard-boiled egg, one half of a muffin, one half of a fruit danish, one half of a slice each of cheddar and mozzarella cheeses, one half of a banana, coffee or tea, and fruit dessert.

The energy (usual dinner, 733 kcal; intervention dinner, 730 kcal) and protein (usual, 27 g; intervention, 25 g) provided by the HCD intervention were comparable to that provided by the usual dairy dinners; however, the carbohydrate portion was higher (usual meal, 90 g; intervention, 73 g) and the fat was lower (usual, 27 g; intervention, 24 g). Participants who refused the intervention foods or requested items from the usual menu in addition to the intervention foods received them, with intakes from intervention foods and typical dinner menu items accounted for separately in the analyses. Research assistants served and weighed all foods but did not actively encourage the participants to eat.

### Sample Size Calculations

We used separate power calculations to estimate the number of days of food intake required per resident and the number of participants required. The study was powered

### Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All</th>
<th>HCD in Phase 2</th>
<th>HCD in Phase 4</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at start of study (y)</td>
<td>88.2 ± 3.9*</td>
<td>88.4 ± 3.5</td>
<td>87.9 ± 4.7</td>
<td>.612</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.8 ± 3.6</td>
<td>24.1 ± 3.7</td>
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<tr>
<td>GDS§</td>
<td>5.0 ± 1.1</td>
<td>4.7 ± 1.2</td>
<td>5.3 ± 1.0</td>
<td>.173</td>
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<tr>
<td>SIB** total score</td>
<td>60.8 ± 26.7</td>
<td>62.8 ± 24.1</td>
<td>58.2 ± 30.8</td>
<td>.651</td>
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<tr>
<td>SIB memory subscale*</td>
<td>6.7 ± 3.8</td>
<td>7.3 ± 3.7</td>
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<td>.475</td>
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<tr>
<td>NPI-NH total score*</td>
<td>21.8 ± 17.2</td>
<td>21.7 ± 17.7</td>
<td>19.5 ± 14.3</td>
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<tr>
<td>NPI-NH aberrant motor behavior subscale**</td>
<td>2.5 ± 3.6</td>
<td>2.6 ± 3.9</td>
<td>1.6 ± 2.8</td>
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</tr>
<tr>
<td>LPRS total score*</td>
<td>30.4 ± 12.1</td>
<td>30.0 ± 13.5</td>
<td>30.9 ± 11.6</td>
<td>.851</td>
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<tr>
<td>LPRS disengagement subscale**</td>
<td>7.2 ± 2.1</td>
<td>7.3 ± 2.6</td>
<td>7.1 ± 1.7</td>
<td>.866</td>
</tr>
</tbody>
</table>

Notes: *Expressed as mean ± standard deviation.  
§Body mass index (BMI) (at the start of the study).  
§Severe Impairment Battery (SIB) scores are a mean of two observations per participant, with the exception of two participants who became ill during the study. For the SIB and subsequent test batteries, only those subscales that showed significant associations with outcome measures are included. Total possible scores ranged from 0 to 100.  
**Possible scores ranged from 0 to 14.  
*Neuropsychiatric Inventory-Nursing Home (NPI-NH) Version scores are a mean of two observations per participant, with the exception of two participants who became ill during the study. Total possible scores ranged from 0 to 120.  
**Possible scores ranged from 0 to 12.  
*London Psychogeriatric Rating Scale (LPRS). Total possible scores ranged from 0 to 72.  
**Possible scores ranged from 0 to 12.

Exclusion criteria were: (a) diseases requiring nutritional intervention (e.g., type 1 diabetes mellitus), (b) prescription of an energy-restricted diet (e.g., for weight-maintenance purposes), (c) swallowing difficulties requiring texture-modified foods, (d) unplanned weight loss, and (e) acute illness. We identified unplanned weight loss using clinical criteria, defined as a loss of 10% or more during the 6 months before the start of the study or 5% or more during the previous month. In addition to a diagnosis of AD, 1 participant had a diagnosis of Parkinson’s disease and a second had bipolar disorder. We obtained this information through chart reviews and interviews with the residents’ primary health care providers (i.e., primary care physicians, attending registered nurses, registered dieticians). After our local ethics committee approved the study, we obtained informed consent from the residents’ families or legal guardians.

Thirty-four of the identified eligible residents participated in the study. We identified and actively recruited potential participants until the needed sample size was attained. Some eligible residents did not participate because their legal guardians (a) could not provide consent because of court restrictions (n = 1), (b) were not actively involved in the life of the resident (n = 1), or (c) did not perceive the study to be beneficial to their family members (n = 3). Of the 34 participating residents, 2 did not complete the study because of acute illness and were eliminated from all analyses. Table 1 summarizes the participants’ characteristics.
(0.8 power; $\alpha = 0.05$) to observe a 250 kcal within-resident difference in dinner energy intake, in at least 75% of the participants, during the intervention compared with the baseline period (intervention response). This power analysis was based on our own reports of mean, minimum, and maximum 24-hour and meal-related variability in food intake, measured in a comparable group of 19 elderly persons with probable AD living in institutions (19). Detecting smaller energy differences is unlikely to be clinically relevant or feasible in those with extremely high within-resident intake variability. To explore the associations between intervention response and participant characteristics with a group-level correlation of $0.5 (\alpha = 0.05$, $\beta = 0.20$), we needed 28 participants. Assuming a loss of approximately 20% during the study, we recruited 34 participants.

Cognitive and Behavioral Assessments

We assessed the participants’ cognitive abilities by administering the Severe Impairment Battery (23) and Global Deterioration Scale (24). We assessed behavioral disturbances using the Neuropsychiatric Inventory-Nursing Home Version (25), whereas we determined behavioral function by administering the London Psychogeriatric Rating Scale (LPRS) (26,27). Table 1 shows selected mean scores. Details of the administration of assessments have been reported elsewhere (21).

Weight

Body weight, expressed as BMI (and measured in kilograms per square meter), was measured on day 1 of the study and on the last day of every phase.

Statistical Analyses

We compared mean intervention versus baseline energy, protein, fat, and carbohydrate consumption using the Student $t$ test, at both the group level and for each participant. We limited comparisons to days having dairy, and consequently intervention, dinners.

We adjusted the data to account for the fact that participants could have eaten both intervention foods and those served on the typical menu. To capture the effect of consuming the intervention foods, rather than traditional foods, we calculated an Intervention Success Score (ISS) for each participant to quantify the intervention response for each intervention dinner as follows:

$$
ISS = \frac{[\text{dinner intake during intervention (kcal)}] - [\text{mean dairy dinner intake during baseline (kcal)}] \times [\% \text{dinner energy derived from intervention foods}]}{[\% \text{dinner energy derived from intervention foods}]}
$$

We used the mean ISS for each participant in subsequent analyses of participant characteristics predictive of intervention response.

Similarly, we calculated the effects of the intervention on macronutrient intakes for each participant by replacing energy in the above formula by each of the macronutrients (in grams).

We derived habitual macronutrient preference by calculating the mean percentage of 24-hour energy intake obtained from each of the macronutrients during the entire baseline phase.

We used several regression approaches to explore associations between participant characteristics and ISS. Each participant’s mean ISS was regressed against habitual macronutrient preference, BMI, and total scores for the Severe Impairment Battery, Global Deterioration Scale, and LPRS assessments, using the reciprocal variance of mean ISS as a weighting variable. We used the $R^2$ selection procedure and stepwise regression to explore associations between the ISS and specific Severe Impairment Battery and LPRS subscales.

Because many behavioral disturbances, as assessed by the Neuropsychiatric Inventory-Nursing Home Version, are likely to be grouped into a few syndromes via factor analysis (28,29), we regressed the mean ISS against composite scores derived from previously published Neuropsychiatric Inventory factor loadings from a similar, but larger sample ($n = 162$) than the current group (28). In addition, we conducted factor analysis on the current database for post hoc exploratory purposes and to confirm the above results.

RESULTS

Intervention “Success”

Group mean analyses suggest that intake was greater during the HCD intervention compared with baseline (Figure 1 shows mean meal-related and 24-hour baseline and intervention energy intakes), with an increase (mean $\pm SD$) of 119.4 $\pm$ 115.5 kcal at dinner ($p < 0.001$) and a 24-hour increase of 109.6 $\pm$ 141.8 kcal ($p < 0.001$), whereas we observed no change at all other meals. This improved energy intake was entirely explained by enhanced mean carbohydrate consumption (Figure 2). Consumption of protein and fat were unchanged.

For participants who received the HCD intervention in phase 4, neither mean 24-hour energy intake (washout,
1693 ± 350 kcal vs baseline, 1665 ± 385 kcal; p = .462) nor dinner intakes (washout, 548.2 ± 198.0 kcal vs baseline, 556.1 ± 200.0 kcal; p = .765) differed between baseline and washout before starting the HCD intervention, suggesting that intakes were at baseline levels for all participants at the start of the HCD intervention.

At the participant level, 19 of 32 residents significantly increased their dinner energy intake during the HCD intervention compared with baseline (α = .05; Figure 3, top), whereas 15 of 32 participants had enhanced 24-hour intakes. The overall mean percentage of energy at dinner derived from intervention foods was 88.7 ± 21.1 kcal, suggesting that they were generally well accepted. Although 29 of 32 participants derived more than two thirds of their dinner energy from intervention foods (Figure 3, middle), some residents requested nonintervention foods. Thus, the ISS (Figure 3, bottom) was derived to reflect the change in dinner energy consumption during the intervention that could be attributed to the intervention foods. The ISS was significantly greater than zero, reflecting enhanced dinner intake attributable to the intervention foods, for 20 of 32 participants. Mean ISS for those who received the HCD intervention in phase 2 (134.4 ± 123.7 kcal) versus those in phase 4 (81.9 ± 94.2 kcal) were not different (p = .1981; with extreme observation from phase 2 reserved [ISS = 502.2 ± 400.6 kcal]; p = .348).

**Effect of the Intervention on Dinner Macronutrient Intakes**

Consistent with group-level analyses, 26 of 32 participants consumed more (α = .05) carbohydrate during the HCD intervention compared with baseline, whereas 6 participants showed no difference (differences adjusted by proportion of carbohydrate from intervention foods). Importantly, protein intake either improved (12 of 32 participants) or was unaffected (14 of 32 participants) in most participants. Fat intake was unchanged in 13 of 32 participants, decreased in 12 of 32 participants, and increased in the remaining residents.

Because protein intake is a concern in this population (19), we studied the association between ISS and the adjusted difference in protein intake between the intervention dinners and baseline. We found no association (p = .396), suggesting that changes in intake resulting from the intervention were not associated with reduced protein intake.
Habitual Macronutrient Selection as a Predictor of Intervention Success

Increased habitual preference for carbohydrate was a positive predictor of ISS (Figure 4, left). With the extreme observation reserved (ISS = 502 kcal, baseline carbohydrate intake = 61%), the significance of the association was borderline (b value = 8.7, p = .053; all subsequent relationships explored remained significant [p < .05] with the extreme observation reserved). Conversely, a decreased habitual preference for fat predicted greater intervention success (b value = −13.9, p = .010), whereas habitual intake of protein was not associated with ISS (p = .808).

Association With Body Weight

We found no significant change in group mean body weight during the intervention (increase of 0.36 ± 1.12 kg, p = .076), possibly because of the short intervention period.

Body mass index was positively associated with ISS (Figure 4, middle), suggesting that those with low BMIs were most resistant to the intervention. Despite this, 3 of 5 participants with BMIs less than 20 kg/m² and 7 of 14 participants with BMIs between 20 and 24 kg/m² increased their intakes above baseline levels. To determine whether changes in body weight before the onset of the HCD intervention affected the association between ISS and BMI, we included in the model the difference in body weight measured on the first day of the HCD intervention and body weight measured during the baseline phase; however, we observed no effect (p = .847).

Associations With Cognitive and Behavioral Assessments

Those with greater degrees of cognitive impairment, as measured by the Severe Impairment Battery, received greater benefit from the HCD intervention (Figure 4, right). Compared with the other subscales, memory was the best predictor, with greater intervention success occurring in those with poorer memories (b value = −10.6, p = .002). Consistent with the Severe Impairment Battery, those with greater cognitive dysfunction, assessed by the Global Deterioration Scale, benefited more from the intervention (b value = 30.2, p = .04).

The association between the LPRS total score and ISS was not significant (p = .2748). However, compared with the other subscales of the LPRS, disengagement was the LPRS subscale most strongly associated with ISS (b value = 14.8, p = .008), predicting greater intervention success in those with increased disengagement.

An analysis of behavioral problems using the factor loadings of Frisoni and colleagues (28) showed a borderline negative relationship between the “psychosis” factor and ISS (b value = −58.7, p = .06). Further exploration of the dominant subscales showed that aberrant motor behavior (b value = 12.0, p = .03), delusions (borderline significant; b value = −10.3, p = .077), and disinhibition (b value = −29.3, p = .02) were likely associated.

Factor analysis of the current database yielded three factors (described elsewhere [16]), of which those with increased “activity disturbance” were more likely to enhance their intakes with the intervention (borderline significant; b value = 36.3, p = .06). Consistent with the analyses using previously published factor loadings (28), further analyses showed that increased aberrant motor behavior predicted greater intervention success (b value = 12.2, p = .03).

DISCUSSION

In this investigation, we wanted to determine whether replacing traditional dinner foods with a high-carbohydrate meal was an efficacious means to enhance habitual intake in seniors with AD. We also identified characteristics that are predictive of a positive intervention response. The intervention resulted in overall increased group mean energy intake, explained by enhanced carbohydrate consumption. At the level of the individual, most participants increased their intake with this intervention, including many with low BMIs. Nevertheless, as with our previous studies (21), participants with lower BMIs were more resistant to the intervention. Characteristics identified as being predictive of a positive intervention response include increased preference for carbohydrate; greater cognitive impairment; particularly memory deterioration; greater aberrant motor problems; and increased disengagement.

Well recognized is that the onset of a variety of disruptive behaviors with AD progression is associated with difficulty in feeding (17). These behavioral difficulties become more problematic throughout the day [i.e., “sundowning” (30)], making dinner a particularly vulnerable meal. Not only do the lowest intakes occur at dinner in those with greater...
behavioral difficulties and low BMIs (19) but food selection shifts from proteins to carbohydrate-containing foods (16). Yet, current nutrition interventions (31–33) do not accommodate circadian changes in intake patterns that occur with disease progression. By targeting the least-consumed meal, dinner, and altering the traditional foods served to parallel the types of food usually eaten at the best-consumed meal, breakfast (19), the current intervention successfully enhanced both dinner and 24-hour intakes in those with greater cognitive and behavioral problems.

With progression of AD, there may be an increased preference for sweet (15) or high-carbohydrate foods (16), particularly in those with increased behavioral difficulties, expressed primarily at dinner (16). Our study specifically included more carbohydrates to account for changes in macronutrient selection and showed that participants with a habitual carbohydrate preference were more likely to enhance their dinner intake with this intervention. Importantly, although carbohydrate intake increased, and thus energy consumption was enhanced, this was not at the expense of protein intake. Indeed, 12 of 32 participants increased their dinner protein consumption. Thus, by capitalizing on the changing food preferences of the individual, rather than serving traditional dinners that are not well consumed by those with behavioral difficulties (19), intake may be increased in a difficult-to-feed population.

Although the data support an argument to provide foods containing higher amounts of carbohydrate at dinner, the fact that HCD intervention foods were easily consumed, and most were hand-held, may also have contributed to the intervention success. Higher physical disability (as measured by the LPRS) was predictive of poor intake at dinner, and not at breakfast and lunch (19), in a comparable clinical population, indicating that some may have required increased eating assistance by the evening meal. Although participants in our study did not require feeding assistance, according to clinical assessments, unmet needs by this meal may have contributed to poor habitual dinner intake that could be overcome by the intervention foods.

Further studies evaluating the long-term response to the intervention are needed, including an investigation of whether increased intake can be sustained, and whether this increase results in body weight gain in the long term. In addition, we do not know whether our results would extend to other populations, such as elderly persons without dementia living in institutions or those with more advanced disease (i.e., those likely requiring feeding assistance or texture-modified foods). Our results suggesting that residents with higher cognitive functioning are less likely to respond to this intervention nevertheless indicate that it should be reserved for cognitively impaired populations, especially those with specific behavioral difficulties.

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GERIATRIC MEDICINE
PROFESSOR/ASSOCIATE PROFESSOR
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The Department of Family and Community Medicine and the Garrison Institute for Healthy Aging at Texas Tech University Health Sciences Center in Lubbock, Texas is seeking a senior level geriatrian to provide leadership for all of the school of medicine’s clinical geriatric programs and to assume an endowed chair in geriatric medicine.

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