Upright Posture and Postprandial Hypotension in Elderly Persons

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Background: **Syncope and falls are common in elderly persons and often result from the interaction of multiple clinical abnormalities. Both orthostatic hypotension and postprandial hypotension increase in prevalence with age.**

Objective: **To determine whether meal ingestion enhances orthostatic hypotension in elderly persons.**

Design: **Controlled paired comparison.**

Setting: **Clinical research center.**

Patients: **50 functionally independent elderly persons recruited from local senior centers ($n = 47$) and from patients hospitalized with an unexplained fall or syncope ($n = 3$) (mean age, 78 years [range, 61 to 96 years]). Twenty-five participants (50%) were taking antihypertensive medication.**

Measurements: **Sequential head-up tilt-table testing at 60 degrees was performed before and 30 minutes after ingestion of a standardized warm liquid meal that was high in carbohydrates. Heart rate and blood pressure were continuously monitored.**

Results: **Meal ingestion ($P < 0.01$) and time spent upright ($P < 0.001$) were significantly associated with systolic blood pressure, but no significant interaction was found between meal ingestion and time spent upright ($P > 0.2$). These findings suggest that the association between meal ingestion and head-up tilt-table testing were additive and not synergistic. However, the proportion of participants with symptomatic hypotension increased during head-up tilt-table testing after meal ingestion (12% during preprandial testing and 22% during postprandial testing). Symptomatic hypotension tended to occur more often and sooner after meal ingestion than before meal ingestion ($P = 0.03$).**

Conclusions: **Meal ingestion and head-up tilt-table testing are associated with increasing occurrences of symptomatic hypotension. After meal ingestion and head-up tilt-table testing, 22% of functionally independent elderly persons had symptomatic hypotension.**

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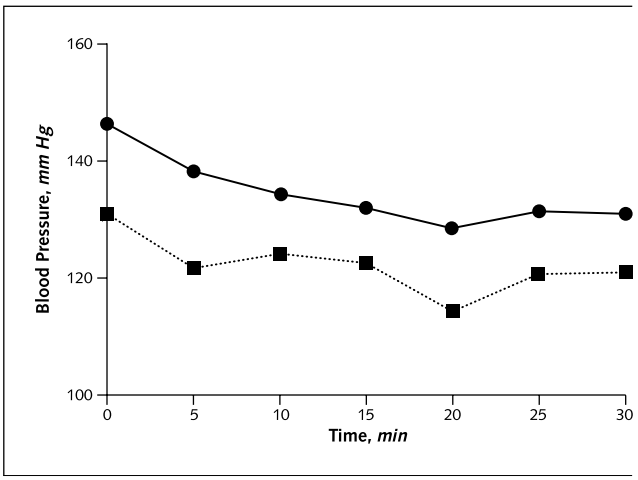
Syncope and falls are common in elderly persons, resulting in significant morbidity and mortality. Aging is associated with changes in cardiovascular structure and function that predispose elderly persons to orthostatic and postprandial hypotension (1). Although postprandial hypotension is cited as a potential cause of falls and syncope, previous investigators have measured postprandial declines in blood pressure in the supine or sitting position. These studies did not demonstrate that postprandial hypotension by itself is an important risk factor for falls or syncope (2). Because falls in elderly persons are often due to the interaction of multiple coexistent clinical abnormalities (3), we hypothesized that postprandial and orthostatic hypotension would be synergistic, resulting in symptomatic hypotension in a subset of elderly persons. We therefore sought to evaluate in a controlled manner whether meal ingestion enhances orthostatic hypotension in a cohort of elderly persons.

Methods

Participants were recruited from local senior centers in the community surrounding the Columbia Presbyterian Medical Center ($n = 47$) and from patients hospitalized with an unexplained fall or syncope ($n = 3$). Persons who agreed to participate underwent history taking, physical examination, and resting 12-lead electrocardiography. Exclusion criteria were age younger than 60 years, presence of clinical coronary artery disease or congestive heart failure, systemic hypotension (systolic blood pressure < 85 mm Hg in the sitting position), diabetes mellitus, Parkinson disease, atrial fibrillation or atrial tachyrhythmia, more than one premature ventricular or atrial beat on a standard electrocardiogram, second-degree heart block, or a pacemaker.

Currently prescribed medications were not withheld, and each participant's medical regimen had been stable for at least 2 weeks. All participants took their medications at 8:00 a.m. and reported to the Autonomic Function Laboratory in the fasting state at 9:00 a.m. After an intravenous line was inserted in the left antecubital vein and leads for electrocardiographic monitoring were attached, the participant rested in a supine position for 15 minutes. Heart rate and blood pressure were recorded and stored on a computer, the latter by using a noninvasive beat-to-beat monitor (Finapres, Ohmeda, Madison, Wisconsin). The study was a controlled paired comparison of the hemodynamic response to upright tilt-table testing before and after meal ingestion.

Figure 1. **Average change in systolic blood pressure during preprandial (*circles*) and postprandial (*squares*) tilt-table testing in 50 study participants.**



The figure underestimates the associations of meal ingestion with decrease in blood pressure because participants in whom tilt-table testing was prematurely terminated as a result of severe hypotension are not included in the later stages of the tilt analysis. Associations were found between systolic blood pressure and time spent upright ($P < 0.001$) and meal ingestion ($P < 0.01$), but no interaction was found between meal ingestion and time spent upright ($P > 0.2$).

Participants underwent two sequential head-up tilt-table tests at 60 degrees for 30 minutes before and 30 minutes after ingestion of a standardized meal. A tilt-table test was considered positive if it was terminated prematurely because of symptomatic hypotension with a systolic blood pressure less than 80 mm Hg.

In the sitting position, participants ingested a standardized liquid meal over 5 minutes, as recommended by Jansen and Lipsitz (4); however, we modified the meal so that caloric content was normalized for body surface area and the meal was warmed to 55 °C.

Beat-to-beat hemodynamic measurements were averaged for each 5-minute interval of tilt-table testing. Kaplan–Meier estimates of time to a positive result on preprandial and postprandial tilt-table testing were computed. Two-way repeated-measures analysis of variance with interaction terms was used to test for differences in systolic blood pressure over time and between preprandial and postprandial testing. We used a multivariate approach to repeated-measures analysis in participants for whom data were complete ($n = 39$). Both independent variables—time after tilt-table testing and meal ingestion (preprandial vs. postprandial)—were considered as within-subject factors. We also analyzed all available data by using a univariate approach with the Geiser–Greenhouse correction (5). To evaluate whether symptomatic hypotension occurred earlier after meal ingestion (compared with before meal ingestion), we tested whether the median of the paired differences in time to syncope was zero by using the sign test and calculated an exact P value based on the binomial distribution (5). All analyses were performed by using SPSS/PC+ software, version 6.1 (SPSS, Inc., Chicago, Illinois).

RESULTS

The mean age of the participants was 78 years (range, 61 to 96 years), and 68% were female. Sixty percent had had a self-reported fall in the previous year (all 3 participants who were hospitalized with an unexplained fall or syncope and 27 [57%] of the participants recruited from local senior centers). Forty-four percent of participants had hypertension. Twenty-five participants were receiving antihypertensive therapy, of whom 10 were taking more than one antihypertensive agent.

Changes in average systolic blood pressure with head-up tilt during preprandial and postprandial tilt-table testing are shown in **Figure 1**. Average systolic blood pressure decreased progressively by 16 mm Hg (95% CI, 8 to 23 mm Hg) after 30 minutes of head-up tilt-table testing before meal ingestion and by 16 mm Hg (CI, 9 to 23 mm Hg) after 30 minutes of testing after meal ingestion. The difference between the postprandial and preprandial average decrease in systolic blood pressure was 0.2 mm Hg (CI, −7 to 7 mm Hg). Average diastolic blood pressure did not change significantly. The average heart rate increased 10 beats/min (CI, 7 to 14 beats/min) preprandially and 12 beats/min (CI, 8 to 16 beats/min) postprandially.

Both meal ingestion ($P < 0.01$) and time spent upright (0 to 30 minutes) ($P < 0.001$) were significantly associated with systolic blood pressure, but no significant interaction between meal ingestion and time spent upright was found ($P > 0.2$). The latter absence of interaction indicates that the rate of decrease in blood pressure with head-up tilt was similar before and after meal ingestion and suggests that the effects of meal ingestion and head-up tilt were additive and not synergistic.

Meal ingestion was associated with an 8–mm Hg (CI, 3 to 14 mm Hg) decline in systolic blood pressure that was additive to the orthostatic response. The number of elderly persons with symptomatic hypotension increased from 6

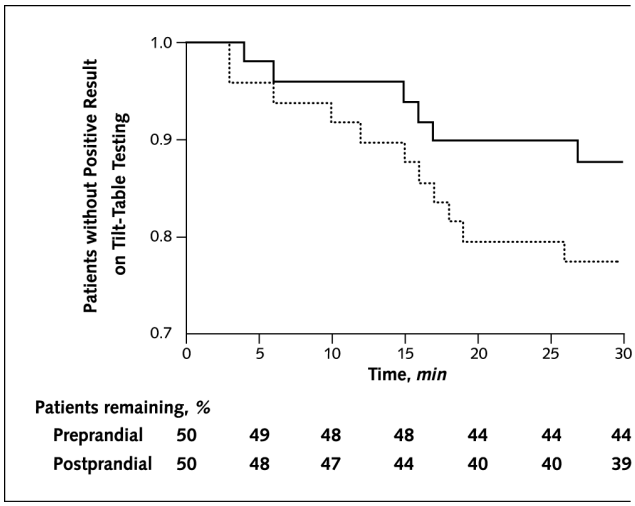
(12%) during preprandial head-up tilt-table testing to 11 (22%) during postprandial testing. **Figure 2** shows a Kaplan–Meier plot comparing time to symptomatic hypotension during preprandial and postprandial head-up tilt-table testing in all participants. Symptomatic hypotension tended to occur more often and sooner after meal ingestion than before meal ingestion ($P = 0.03$, sign test).

DISCUSSION

Postprandial hypotension was first described in a cohort of institutionalized elderly persons (2). Numerous investigations have confirmed postprandial reduction in blood pressure in elderly persons (6, 7), but its clinical significance is unknown. In a case–control study, Lipsitz and colleagues (2) found no statistically significant difference in the degree of postprandial hypotension in supine elderly persons with syncope and those without syncope (15 ± 2 mm Hg vs. 11 ± 4 mm Hg, respectively). A subsequent study found no postprandial decline in blood pressure in healthy elderly persons in the supine position (8). Vaitkevicius and associates (9) found that sitting during the postprandial period was associated with a more severe decline in postprandial blood pressure among nursing home residents. These findings are consistent with the hypothesis that falls and syncope in the elderly have a multifactorial cause and often result from the interaction of multiple coexistent clinical abnormalities. In this study, we show that among elderly persons, meal ingestion does not alter the magnitude of orthostatic hypotension and the effects of postprandial hypotension and orthostatic hypotension are additive but not synergistic.

Our results contrast with those of other investigators who sought to determine whether postural changes enhance postprandial hypotension. In a controlled trial of 20 participants who stood up 90 minutes after eating (when the hemodynamic effect of meal ingestion is waning), Imai and coworkers (10) found no augmentation of postprandial changes. Ooi and colleagues (11) found that orthostatic hypotension during standing was ameliorated postprandially in a large cohort of nursing home residents. That study used only a single cuff measurement of changes in orthostatic blood pressure. By using continuous beat-to-beat monitoring, we may have identified hemodynamic alterations that previous studies missed. In addition, our participants underwent head-up tilt-table testing 30 minutes after meal ingestion, during which time the greatest postprandial reductions in blood pressure occur. This represented a clinically relevant interval because meal ingestion typically lasts 30 minutes in many elderly persons.

Figure 2. **Association between meal ingestion and time to symptomatic hypotension.**



An increased percentage of the same participants had symptomatic hypotension after meal ingestion. The solid line represents preprandial data and the dotted line represents postprandial data. The percentage of participants with a positive result on tilt-table testing was higher after meal ingestion ($P = 0.03$).

We carefully controlled the caloric composition and quantity of the meal. Meal composition and temperature have been shown to affect the degree of postprandial hypotension; a high carbohydrate content and warmer temperature are known to cause substantially more hypotension than protein or fats and colder foods (12). We used a higher percentage of carbohydrates than did other studies and warmed the liquid meal to 55 °C to amplify the postprandial hemodynamic response. The meal that we used is comparable to the ingestion of a turkey sandwich and a cola beverage.

Our study has limitations. We used head-up tilt-table testing as the hemodynamic stress. Compared with active standing, tilt-table testing causes more venous pooling and greater hypotension. Thus, our results may overestimate the association of eating and active standing with blood pressure in functionally independent elderly persons. However, the results may be relevant to a frailer elderly population that is at higher risk for falls and syncope. Medications were not withheld during the study, a factor that may have confounded our results. Symptomatic hypotension occurred in 8 of 25 (32%) participants taking antihypertensive medications compared with 3 of 25 participants not taking such medications ($P = 0.17$). Thus, we cannot

exclude the possibility that some of the observed occurrences of symptomatic hypotension resulted from a combination of antihypertensive medication and the interventions. However, our finding is consistent with previous work showing that long-term use of one or a combination of cardiovascular medications administered before postural change or ingestion of a meal does not seem to worsen orthostatic or postprandial hypotension (13).

Our data indicate that the combination of ingestion of a warm meal high in carbohydrates and upright posture is associated with symptomatic hypotension in a significant number of functionally independent elderly persons. In the evaluation of an elderly patient with falls, syncope, or dizziness, attention to the relationship of these symptoms to meal ingestion or postural change may be useful in identifying the potential cause.

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