Liquid meal enhances balance following exercise in a healthy older population

Leah Paige Versteegen

The University of Montana

Let us know how access to this document benefits you.
Follow this and additional works at: https://scholarworks.umt.edu/etd

Recommended Citation
https://scholarworks.umt.edu/etd/6285

This Thesis is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact scholarworks@mso.umt.edu.
Permission is granted by the author to reproduce this material in its entirety, provided that this material is used for scholarly purposes and is properly cited in published works and reports.

**Please check "Yes" or "No" and provide signature**

Yes, I grant permission

No, I do not grant permission

Author's Signature: [Signature]

Date: 12/09/03

Any copying for commercial purposes or financial gain may be undertaken only with the author’s explicit consent.
Liquid meal enhances balance following exercise in a healthy, older population

by

Leah Paige Versteegen

B.S. Furman University, 1999
B.A. Furman University, 1999

Presented in partial fulfillment in requirements
for the degree of

Master of Science

The University of Montana

Health and Human Performance

2003

Approved by:

Chairperson

Dean, Graduate School

12-9-03

Date
Liquid meal enhances balance following exercise in a healthy, older population.

Director: Steven E. Gaskill

Abstract

Purpose: This study examined the effects of a liquid meal on self-selected exercise performance and standing balance during exercise in healthy, older mall-walkers. Methods: Seven healthy mall-walkers (age=71.6±5.4 years) were recruited to walk for one-hour at a self-selected pace on each of two mornings. The subject was fed either a standardized liquid meal (LM) 30 minutes prior to walking or remained fasted (FST) for 12 hours prior to walking. Time required to complete each lap and heart rate was recorded throughout each of the exercise sessions. Blood/glucose levels and balance assessments, the one-legged stance test (OLST) and Sharpened Romberg test (SR), were measured immediately prior to and after each exercise trial. Results: The primary finding indicated that a liquid meal is associated with better balance in elderly men and women after moderate exercise. Three out of four of the balance tests showed a significantly greater (p<0.05) time in balance for the LM trial when compared to the FST trial. For both variables of SR (eyes open and eyes closed) and the OLST eyes closed, the trial x time interaction was significant (F=15.538; F=19.747; F=20.680) with means comparisons revealing that FST balance was significantly lower post exercise than LM balance. For the variable of OLST eyes open, the trial x time interaction was not significant, however balance was significantly higher (F=8.629) during the LM trial compared to the FST trial. OLST eyes open balance was also significantly lower (F=6.194) post exercise compared to pre exercise. No significant difference between trials was found in exercise performance, as indicated by RPE, walking pace and/or heart rate. Blood glucose levels were significantly higher (F=7.746) post exercise for the LM trial compared to the FST trial. Conclusions: Results indicate that the liquid meal (LM), Ensure, is associated with better balance in elderly men and women after moderate exercise. Therefore, it is apparent that older populations should be encouraged to eat prior to morning exercise in order to maintain balance and thus minimize the risk of falling during or after exercise.
Table of Contents

Abstract

Chapter One: Introduction
- Introduction 1
- Purpose of Study 3
- Research Hypothesis 4
- Rationale of the Study 4
- Limitations 4
- Delimitations 5
- Definition of Terms 6

Chapter Two: Review of Literature
- Exercise and Associated Health Benefits for Older Populations 8
- Cognitive Function and Physical Activity 10
- Sensori-Motor Function and Physical Activity 12
- Prevalence of Exercise in Older Populations 13
- Relationship between Cognitive Function and Nutrition 15
- Effects of Supplementation on Physical Performance 17
- Balance Testing Methodology 19

Chapter Three: Methodology
- Setting 20
- Subjects 20
- Procedure 21
- Measures 21
  - Balance Assessments 21
  - Blood Glucose 22
- Analysis of Data 23

Chapter Four: Results
- Subject Characteristics 24
- Measures of Exercise Intensity 24
- Blood Glucose 24
- Balance 25

Chapter Five: Discussion and Conclusion
- Discussion 27
- Conclusion 28

Tables and Charts 30

References 40

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
List of Tables

<table>
<thead>
<tr>
<th>Table/Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Descriptive Data</td>
<td>30</td>
</tr>
<tr>
<td>Table 2</td>
<td>Changes in HR and RPE</td>
<td>31</td>
</tr>
<tr>
<td>Figure 1</td>
<td>Changes in Blood Glucose</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Changes in Balance for SR</td>
<td>33</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Changes in Balance for OLST</td>
<td>34</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Forms and Questionnaires</td>
<td>35</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Chapter One

INTRODUCTION

Introduction

A number of studies have reported that regular physical activity can increase longevity and attenuate many of the physiological declines that accompany aging. Occurrence of fatal incidences, such as sudden myocardial infarction, as well as chronic problems, such as cardiovascular disease, osteoporosis, unfavorable lipoprotein levels, obesity, muscle weakness, decreased immune function, and physiological depression can all be minimized with regular physical activity (1-6). Despite these findings, only approximately 30% of individuals over the age of 65 report participation in regular physical activity (4; 6; 7). The reasons behind such low levels of participation may be numerous, but one of the major factors influencing physical activity in older persons is fear of injury and possible death. Lack of education about the benefits and risks associated with physical activity and availability of individualized exercise prescription for older persons contribute to the belief that exercise is unsafe (6; 8). Therefore, while regular exercise is often recommended as a means of improving health and physical function, the effects of regular exercise on various fundamental systems in older persons populations has not been adequately shown.

Previous research demonstrating the exercise response in older populations has involved physiological changes that occur over an extended training period. The response of cognitive function to a structured physical activity program is perhaps the
most extensively studied of these physiological changes (9; 10). This is not surprising, as cognitive decline is closely related to the aging process (11) and adequate cognitive function is necessary for maintenance of independent living and critical for personal function. Overall, studies examining the effects of regular physical activity on cognitive functioning in older persons have demonstrated that regular activity attenuates the cognitive decline associated with aging (10; 11). In addition to measures of cognitive function, functional sensori-motor tests are often used to determine the side effects of exercise training in older persons (5; 11; 12). These tests are used to evaluate the effects of exercise on strength, balance, reaction time and neuromuscular control. Although past data is conflicting, a recent study by Lord and Castell (12) has demonstrated a general improvement in strength, balance and reaction time following a 20-week training program in older subjects.

In contrast, few studies have attempted to identify the effects of a single bout of exercise on cognitive or sensori-motor function, and no studies have explored this in older populations with any mode of exercise. Although some previous research has shown no change in cognitive function from pre-exercise to post-exercise in a group of fit, young males (13; 14), others have demonstrated that acute physical activity may facilitate cognitive performance (15-17).

In addition to physical activity, diet may also alter age related changes in cognitive function (18; 19). Several studies have used glucose and carbohydrate supplementation to examine the effects of glucose intake on performance of non-memory and memory cognitive tasks in older populations (20-25). Consistent results suggest that poor glucose regulation is a primary determinant of poor cognitive function in older
persons. In addition, glucose will enhance memory and non-memory tasks in older subjects, with both poor and normal glucose regulation. The author is not aware of any studies relating sensori-motor function to diet.

Extensive research has been conducted on feeding, particularly with carbohydrate-rich beverages, during exercise and the exercise response (26-29). Most of this research has focused on the population of endurance-trained males. These studies have shown that carbohydrate feeding (CHO) is related to increased performance, increased plasma/glucose concentration, and an increase in muscle glucose utilization. CHO supplement studies have also been conducted examining the effects of CHO on performance using different modes of exercise (30), phases of the menstrual cycle (31), genders (32), and exercise in adverse conditions (33-35). Surprisingly, the author is unaware of any previous research reporting the effects of feeding on self-selected exercise intensity and exercise performance in older populations. Perhaps the main relationship between feeding and exercise in the elderly pertain to maintenance of sensori-motor function rather than an increase in exercise performance. These questions have not been adequately addressed by previous research.

Purpose

The purpose of the present study is to determine the relationship between a liquid meal and self-selected exercise intensity, exercise performance, and balance as a measure of sensori-motor function during moderate exercise in a healthy, older population.
**Research Hypothesis**

The liquid meal prior to exercise will increase the total distance walked and self-selected exercise intensity, as well as promote balance maintenance throughout exercise in a healthy, older population.

**Rationale for the Study**

We are unaware of any previous research that has reported the effects of a liquid feeding prior to exercise in older populations. It is possible that improving nutritional status by ingesting a liquid meal prior to exercise in this population will increase exercise performance and/or maintain balance during exercise, both of which are major limitations in exercise prescription for older persons. Results from this study could be used to educate older populations on reducing risk of falls during exercise by maintaining blood/glucose through adequate feeding prior to activity. It is also possible that older populations can increase exercise intensity and duration through feeding prior to exercise, thus maximizing the physical and mental benefits they can attain from regular exercise.

**Limitations**

i. **Pre-trial standardization:** Activities in which the subjects engage prior to and between trials will not be regulated. However, trials will be at least 3 days apart, thus minimizing possible training effects. In addition, subjects will be required to fast for 12 hours prior to the fasted exercise trial or consumption of the standardized liquid breakfast in order to limit effects of pre-trial diet.
ii. Inter-subject differences: Rates of progress with the balance testing cannot be measured or accounted for. In order to minimize the practice effect, all subjects will have the opportunity to practice the balance tests 3 times prior to beginning the exercise trials on each day.

iii. Instrumentation: It is assumed that the One-Legged Stance Test (OLST) and Sharpened Romberg Test (SR) are accurate measures of balance. It is further assumed that blood obtained via a finger prick method is characteristic of mixed venous blood.

iv. Intertester Reliability: It is assumed that all administrators present for the trials will record accurate measurements of balance and obtain adequate blood samples for blood/glucose assays. All administrators will be equally trained on how to take blood/glucose samples and administer the OLST and SR.

v. Exercise level: All subjects will be instructed to self-select their pace of walking and to walk alone during the testing or, at a minimum to not allow a walking partner to influence their walking pace.

**Delimitations**

i. Type of Subjects: The subjects will consist of older (>60 years) volunteers, mainly recruited at Southgate Mall, Missoula, MT, all of whom participate in regular exercise and are physically healthy.

ii. Balance measure: The One Legged Stance Test (OLST) and the Sharpened Romberg Test (SR) will measure the balance of the subjects during exercise.
iii. Learning effects: Each subject will be given three practice trials for each test in an effort to negate the learning effect. This number was selected based on reports by Gronwall (1977) of moderate practice effects stopping at the second administration.

Definition of terms

1. Older: age >60

2. Physically Healthy: The following conditions are confirmed only by self-report by the subjects participating in the study.
   a. No history of CHD
   b. Non-diabetic
   c. No recent hospitalization (within last 6 months)
   d. No physical disability (prosthetics; breaks or sprains)

3. LM: Liquid meal

4. CHO: Carbohydrate supplementation trial

5. FST: Fasted trial

6. Cognitive Function: The automatic means by which people select and process information as determined by how one assigns meaning to events and to what one attributes the causes.

7. Sensori-Motor Function: Interaction between the sensory nerves that bring information from the periphery to the brain for processing, and the subsequent impulses that are transmitted along the motor nerves to create reactions.

8. OLST (One Legged Stance Test): A balance test which requires the subject to
maintain balance on one leg while lifting the other leg only a few inches off the
ground to better mimic positioning during normal walking activity.

9. SR (Sharpened Romberg test): A balance test that will be performed in a heel-to
toe standing position with the non-dominant foot forward.

10. RPE (Borg Rating of Perceived Exertion): A numerical scale from 6-20 that has
corresponding verbal phrases ranging from ‘very, very light’ to ‘very, very hard’
(36). Using this scale during exercise allows subjects to verbalize subjective
feelings of systematic fatigue.

Exercise and associated health benefits for older persons

Pertinent to our understanding of the relationship among nutritional status, exercise performance, and sensori-motor function, we must first understand the benefits of exercise for older persons. Elward et al. (4) compared the characteristics of regular exercisers and nonexercisers among 561 randomly selected elderly persons, aged 65 and older, who were enrollees of a health maintenance organization. Of the 561 subjects, only 34% were regular exercisers. Exercisers were slightly younger, reported more positive health perceptions, and were less likely to report hypertension, arthritis, heart disease, and emphysema.

Bijnen et al. (1) investigated the association between physical activity at baseline and mortality 5 years later in 472 older Dutch men. Results indicated that becoming or remaining sedentary was significantly associated with increased mortality risk in comparison with remaining physically active. A combination of the results from recent research, along with recommendations made by the Center for U.S. Disease Control (CDC) and the American College of Sports Medicine (ACSM) (8), prove useful in understanding the dynamics of exercise behavior in older populations, and may assist in developing and encouraging participation in exercise interventions for this population.

Neimann et al. (2) narrowed the focus of their research on exercise in an older population to include only women living in a community setting. 32 apparently healthy, sedentary, elderly, Caucasian women, aged 67 to 85 years, and ten highly conditioned
older women, aged 65 to 84, were recruited. The highly conditioned group consisted of women who were active in endurance competitions and had been training for $11.2 \pm 1.2$ years. Sedentary subjects were randomized to either a walking or callisthenic group, each of which exercised 30 to 40 minutes, 5 days a week for 12 weeks. Serum lipids and lipoproteins, maximal aerobic capacity ($V_O^2_{\text{max}}$), four skin folds, and dietary intake were recorded at baseline and after 5 and 12 weeks. Highly conditioned and lean women, when compared with their sedentary counterparts, had higher HDL-C and lower triglycerides, but similar total serum cholesterol and LDL-C values. However, 12 weeks of moderate cardio respiratory exercise were not associated with an improvement in serum lipid or lipoprotein profiles in previously sedentary older women. Improvements in $V_O^2_{\text{max}}$ for the sedentary population were noted across the 12-week training period. These results indicate that maximal benefits from exercise are obtained with long-term exercise habits in older women.

A second study reported by Niemann et al.(3), focusing on the same population, examined the relationship between cardiorespiratory exercise, immune function, and upper respiratory tract infection. Twelve weeks of moderate cardiorespiratory exercise did not result in any immune function improvement as measured by NK or T cell function. Incidence of urinary tract infection was lowest in the highly conditioned group and highest in the calisthenics control group. In accordance with the previous results, maximal health benefits can be obtained with long-term exercise programs in older women.

Based on the current literature, it is evident that long-term, chronic, exercise is a major component in maintaining physical health for older persons. It is necessary,
however that we also review the benefits that exercise may have on everyday life functions, such as balance, strength, coordination and mental function.

Cognitive Function and Physical Activity

As one of the most extensively studied physiological responses to exercise programs in older populations, there is a great deal of literature on the responses of cognitive function to physical activity. I was unable to find literature that relates single bouts of exercise to cognitive function in older populations; therefore, I have focused on studies that report effects of long-term exercise programs on cognitive functioning.

In an attempt to determine the relationship between cognitive decline in older persons and physical activity, Yaffe et al. (10), examined the association between baseline physical activity and cognitive decline during 8 years of follow-up in older, community dwelling women. All measurements were taken at the homes of the subjects, including weekly self-reported physical activity and cognitive functioning tests at baseline evaluation and again 6 or 8 years later. Subjects with greater baseline physical activity were less likely to develop cognitive decline during the 6-8 year follow-up. This association remained after adjustment for the covariates, including baseline functional and health status, and did not seem to be explained by differences in baseline physical performance measures.

Perrig-Chiello et al. (9) studied short and long-term effects of resistance training on the muscle strength, psychological well being, control beliefs, cognitive speed and memory in normally active older people. As part of The Interdisciplinary Aging Study,
an interdisciplinary longitudinal project, 46 volunteers were recruited and randomly assigned to either a control group or an experimental group. A personality questionnaire to assess psychological and physical well being was completed, as were competence and control beliefs questionnaires, an immediate and delayed free recall test, an immediate and delayed recognition test to assess memory and cognitive speed, and a leg extensor power rig to determine leg extensor power. The experimental group trained for 8 weeks with a workout consisting of a 10 min warm-up, and 8 resistance exercises on machines. The resistance training program did result in increased muscular strength, but did not result in better subjective health ratings, greater sense of well being or improved control belief patterns. The only well-being variable with significant improvement was self-attentiveness. The study did however find positive relationships between physical exercise and cognitive function.

A third study examining the potential interactive effects of exercise and cognitive functioning used walking as the mode and included self rated health and age as predictive measures for cognition. Emery et al. (11) randomly recruited 6,979 men and women form British electoral records and conducted face-to-face interviews regarding health and health beliefs as well as cognitive function, as measured by simple reaction time (SRT) and choice reaction time (CRT). Exercise and health both had interactive effects on reaction time speed and may even modify age-related changes in reaction time.

Although there was no literature found that reviewed the effects of a single bout of exercise on cognitive function in older populations, other populations have been used in such studies. Sparrow and Wright (13) found that short duration aerobic exercise has no effect on cognitive performance in a group of 50 male volunteers from an Australian
Rules football club. These results concur with those of Flynn (14), who found no difference in cognition following six-minute bicycle ergometer tests of varying intensity. Conversely, Gupta et al. (16) found a significant increase in mental work of 50 subjects, aged 19 to 21 years, when physical activity was of 2 and 5 min duration and a significant decrease when the physical work was of 10 and 15 min duration. Similarly, Davey (17) found that mental performance increased following exercise bouts of both 30 seconds and 2 minutes, whereas mental performance after 10 minutes of exercise decreased.

In a review of the effects of exercise on cognitive processes, Tomporowski et al. (15) concluded that the failure to gain a complete understanding of the effects of exercise–induced arousal on cognition appears to be due to a lack of coherent methodology. Thus, additional systematic investigation of the effects of exercise on mental functioning is needed before any conclusions can be drawn.

**Sensori-Motor Function and Physical Activity**

Proficient cognitive function is an important component of every-day living, but is not the only skill necessary to live independently. Sensori-motor function, as often measured by balance, strength and physical reaction time, is equally important and thus has been the focus of ample research in elderly populations. Lord and Castell (5; 12) have completed several studies covering the effects of exercise on sensori-motor function in older persons. In two such studies, subjects enrolled to participate in an exercise program, and along with corresponding control subjects, underwent assessments of strength, reaction time, neuro-muscular control and body sway. When compared to the control group in both studies, the exercise group showed improved quadriceps strength, reaction
time and reduced body sway, which suggests that exercise can improve sensori-motor function in older people. Johansson and Janlo (37) completed a similar study and reported significant improvements in measures of postural sway following exercise trials in an older population.

Conflicting with these studies, however, are results from a pilot study by Lichtenstein et al (38). A random sample of 50 healthy, single, female subjects, 65 years of age or older, was recruited. Subjects were brought to the Gait Analysis Laboratory at Vanderbilt University for baseline measurements of body mass, vision, and balance using a stationary level biomechanics platform. After completion of baseline measurements, the subjects were randomized into control and intervention settings and an exercise program was designed with the intent of improving balance, flexibility, and reaction time. The program was provided in one-hour sessions, twice a day, 4 days a week, for 16 weeks. No consistent change in balance measures between exercise and control groups was detected. Possible factors influencing this were: (1) lack of statistical power to detect observed differences (2) lack of adequate compliance with the exercise program (3) problems with baseline difference between the two groups at the time of the randomization, and (4) lack of efficacy, or inadequate duration, or the exercise program.

**Prevalence of exercise in elderly populations**

Based on what is known about the benefits of exercise for older persons, it would seem that a high percentage of this population would choose to participate in regular activity in order to maintain or enhance their health and sensori-motor functioning. Elward et al. (4) touched briefly on the percentage of participation in regular exercise

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
within older populations. Of the 561 randomly selected persons aged 65 years and older for their study, only 34% were regular exercisers.

McPhillips et al. reported a more extensive look into the exercise patterns of older populations (7). The exercise patterns of 1,140 members of an adult community, aged 50 to 95, were examined. The study participants were part of an ongoing population-based study designed to examine life-style and chronic disease in older adults. By completing a self-administered questionnaire, the subjects ascertained the frequency and duration with which they participated in 14 different leisure-time activities during the two-week period before their clinic visit. With the exception of those who reported no exercise (6.5% of all men, and 11.8% of all women), the exercise patterns of men and women were similar. Only 34% reported moderate to heavy exercise and only 60% of that group did so at least 20 minutes a day, 3 days a week, as recommended by the American Heart Association (AHA), CDC or ACSM. Despite the data showing that a majority of the older community participated in at least light activity during the two-week period noted, very few did so in accordance with the duration and frequency recommended by the AHA, CDC and ACSM.

The Surgeon General, in association with the Center for Disease Control and Prevention, recently published a report on physical activity and health that addresses the recommendations made by the CDC, AHA, and ACSM, in an effort to help educate the American public on the benefits of exercise(6). Summarizing a diverse literature from several fields, including epidemiology, exercise science and medicine, the main goal of this report is to summarize the existing literature on the role of physical activity in preventing disease and on the status of interventions to increase physical activity.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Americans can substantially improve their health and quality of life by including moderate amounts of physical activity in their daily lives. Health benefits from physical activity are thus achievable for most Americans, including those who may have been previously discouraged by the difficulty of adhering to a program of vigorous exercise. For those who are already achieving regular moderate amounts of activity, additional benefits can be gained by further increases in activity level. Research on understanding and promoting physical activity is at an early stage, but some interventions to promote physical activity through schools, worksites, and health care settings have been evaluated and found to be successful. The Surgeon Generals’ report, in conjunction with others such as my own can play a major role in educating the public and encouraging them to make physical activity a regular and sustainable part of their lives.

**Relationship between Cognitive Function and Nutrition**

Recent research has directed attention to a possible relationship between lifestyle and cognitive decline in old age. Amongst the lifestyle practices examined, the importance of diet and nutritional status has generated particular interest. Ortega et al. (18) studied 260 non-institutionalized persons, aged 65 to 90 years, for associations between dietary intake and cognitive performance. They found that a diet with less fat, saturated fat and cholesterol and more carbohydrate, fiber, vitamins and minerals may be advisable to not only improve general health in older populations, but also to improve cognitive function. Greenwood and Winocur (39) also reported on the relationship between overall diet and cognitive function in older populations. They emphasized the
vulnerability of the brain to diet and the need for adequate vitamin intake, especially as people age.

In attempts to better define the impact of certain diet components on cognitive function, several researchers have studied the relationship between glucose regulation and cognitive performance. Manning et al. (21) studied healthy, older volunteers (5 males and 12 females) to determine the effects of glucose on memory and non-memory measures of neuropsychological function. The subjects, who were given a series of neuropsychological tests after drinking glucose or saccharin flavored lemonade, performed better post-consumption of the glucose drink than they did post-consumption of the placebo. Comparable studies and results were reported by Hall et al. (20), Craft et al. (24), and Manning et al. (25).

Similarly, Allen et al. (22) studied 28 elderly individuals, who received either a 16 ounce (452gm) lemon flavored beverage sweetened with 50g glucose or 23.7 mg of saccharin, to evaluate the role of glucose in the performance of a series of memory and non-memory neuropsychological tasks. They concluded that dietary glucose enhances nonverbal mnestic functions in older persons, and may also enhance non-memory tasks of behavioral fluency.

Kaplan et al. (23) varied the typical glucose regulation study by providing the subjects with actual foods rather than mixed drinks. Ten male and ten female free living subjects aged 60-82 were recruited and administered one of four foods on four different trials. The 4 test foods were placebo, glucose drink, instant mashed potatoes or barley. The goal of the study was to determine whether measures of glucose regulation were associated with cognition in healthy elderly persons with normal fasting blood/glucose
and to determine the influence of glucose and common carbohydrate foods on memory and non-memory cognitive performance in these subjects. They found that glucose regulation was associated with cognitive performance in older subjects with normal glucose tolerance. Dietary carbohydrates (potatoes and barley) enhanced cognition in subjects with poor memory or B cell function independently of plasma glucose. Subjects with good baseline performance and B cell function generally performed worse after ingesting carbohydrates. Therefore, individuals with seemingly minor deficits in glucose regulation appear to perform worse on cognitive tests and are most sensitive to beneficial effects of carbohydrates.

Despite the extensive literature that has been published linking nutrition and supplementation to cognitive function, this author is unaware of any studies on the effects of nutrition or supplementation on sensori-motor functions.

**Effects of Supplementation on Physical Performance**

Physical performance can be affected by many variables, diet being one of the main variables. Although a balanced diet has proven to be essential in maintaining a healthy, active lifestyle, carbohydrate ingestion prior to and during exercise is widely accepted as vital to the optimization of performance. The primary purpose of CHO ingestion during continuous exercise is to maintain blood glucose concentration, possibly sparing muscle glycogen, thus possibly improving exercise tolerance during the latter stages of prolonged exercise (26). Due to the known physiological benefits of carbohydrate ingestion during exercise, substantial research has been published on the effects and timing of carbohydrate intake on a variety of exercise performances.
However, little or no research has been conducted on older populations or on populations participating in only moderate intensity exercise of which I am aware. Results from younger populations working at higher intensities may help us to better understand the relationship between carbohydrate intake and exercise performance in our target population.

In two separate studies, el-Sayed et al. (27; 28) examined the effects of carbohydrate ingestion on cycling time and work output. Trained, male cyclists were recruited to perform two exercise tests on the cycle ergometer, one with CHO ingestion and another using a placebo. Results of both studies indicated an increase in both mean power output and distance covered in the given time period following CHO ingestion when compared to the placebo trial. Similar results were found by McConell et al. (29) who found that exercise time to exhaustion increased by ~30% when carbohydrate was ingested by the male cyclist subjects when compared to a placebo trial.

Endurance exercise is not the only mode that can benefit from carbohydrate intake. Haff et al. (30) recruited eight highly resistance trained males to complete isokinetic leg exercises, with either CHO or placebo treatments administered before and during exercise. Although there were no differences in isokinetic performance between the treatments, the CHO treatment elicited significantly less muscle degradation compared to the placebo. Thus, the consumption of a CHO beverage can attenuate the decrease in muscle glycogen associated with isotonic resistance exercise.

Environmental conditions (33-35), gender (32), and exercise during different phases of menstrual cycle (31) have also been manipulated in order to determine if any variations in the effects of carbohydrate on performance can be noted. According to most
research to date, carbohydrate intake before and/or during exercise benefits exercise performance regardless environment, gender, or menstrual cycle phase. The extent of the benefits of carbohydrate on performance with the varying subjects and conditions may not be identical, but nevertheless, carbohydrate intake does benefit exercise performance. One area that current research does not appear to cover is whether or not carbohydrate intake remains beneficial for elderly populations.

**Balance Testing Methodology**

Several balance tests have been used over the years as a measure of sensori-motor function. For the purpose of this study and the restraints due to testing during exercise in a real life setting, it was necessary to find a valid and reliable balance test that required minimal supplies and time to complete. For this reason, the One Legged Stance Test (OLST) and the Sharpened Romberg Test (SR) were chosen in accordance with methodologies reported by Briggs et al. (40), Iverson et al. (41), and Bohannon et al. (42), all of whom used these tests as measures of balance in older subjects.
Chapter Three

METHODOLOGY

Setting

Recruiting and subject testing took place at Southgate Mall in Missoula, Montana. The spectrophotometric analysis of blood samples was completed at the Health and Human Performance laboratory at the University of Montana. All testing methodology was approved by the IRB at the University of Montana, Missoula (Appendix A).

Subjects

Approximately 7 healthy (n= 2M,4F) subjects were chosen to participate in the exercise sessions and were required to attend 3 morning sessions at Southgate Mall, Missoula, Montana. The total group had a mean age of 71.6 years. The exercise subjects were recruited at Southgate Mall from a group of regular mall-walker participants. All subjects chosen to participate had to complete and pass background medical history questionnaires in order to minimize drop-out rates and potential injury associated with testing.

Procedure

The first informative session involved the completion of medical background questionnaires and descriptive data on the subjects. Sample balance testing was administered in order to account for any practice effects that may occur with testing. The protocols for the two exercise sessions were similar to one another as described below.
except for the liquid meal (LM) provided. One trial was completed with the subjects fasted 12 hours and one trial with liquid meal feeding 30 minutes prior to exercise. A repeated measures crossover design was used so that each subject serves as his or her own control and participates in both exercise sessions.

After an overnight fast (12 h), the subject arrived at the mall at 0700. The subject either received a standardized liquid meal, Ensure, or remained fasted throughout the exercise trial. The Ensure drink combines 40g carbohydrates, 9g protein, 6g fat (0.5 of which is saturated), 200mg of sodium, 370mg of potassium and several of the recommended daily vitamins in an 8oz can that totals 250 Calories.

Immediately prior to exercise, baseline balance testing was completed and a blood sample was taken. Polar heart rate monitors were then put on each subject. Subjects were then asked to walk for one hour at a self-selected pace following a designated path in the mall. Subjects were encouraged to walk alone to prevent any influence on one another’s pace and were told to abstain from stopping for water or bathroom breaks unless necessary.

Heart rate was recorded throughout exercise and averaged for each 15 minute period. Time to walk each lap and RPE at the end of each lap was recorded. Balance testing was administered and blood samples were obtained again immediately after the exercise trial.

**Measures**

*Balance assessments:* Balance was measured using two clinically applicable methods, the One-Legged Stance Test (OLST) (40-43) and the Sharpened Romberg Test (SR) (40; 41;
One investigator stood near the subject at all times to prevent falls attributable to the loss of balance. Each test was administered twice, once with eyes open and once with eyes closed. Up to three trials were permitted until subject reached maximal time. If maximum time was not reached, the longest balance time of the recorded trials was used for the data analysis.

The OLST required the subject to maintain balance on one leg, while lifting the other leg only a few inches off the ground to better mimic positioning during normal walking activity. Timing began as soon as the subject lifted the appropriate foot off the ground and ceased if the subject moved the foot they were standing on, touched the suspended foot to the ground, used the suspended foot to support the weight bearing limb, opened their eyes on the eyes closed trial, or reached the maximum balance time of 30 seconds.

The SR was performed in a heel-to-toe standing position with the non-dominant foot forward. Help in assuming the appropriate position was provided to the subject if requested, but ceased when the subject was ready for timing to begin. Timing stopped if the subject moved their feet from the proper position, opened their eyes on the eyes closed trial, or if the subject reached the maximum balance time of 60 seconds.

**Blood Glucose:** Blood samples were analyzed from a finger stick sample (15μl) placed in 100μl of chilled 7% perchloric acid and frozen for later analyses. Blood glucose was determined using an enzymatic spectrophotometric method in the Health and Human Performance lab. Frozen blood samples were thawed and centrifuged for 10 min (Jouan MR22) to separate supernatant. A 5uL sample of supernatant was removed with a
micropipette, combined with 500uL Sigma Infinity Glucose Reagent, and left to incubate for 3 minutes. Samples were run through the spectrophotometer (Spectronic 410, Mr. Sipper) for glucose analysis.

Analysis of Data

All descriptive data is expressed as mean ± standard deviation (SD). Average HR (computed as the average for each 15 minute period during the 60 minute exercise session), and balance time were analyzed using a 2 (trial) x 4 (time) and 2 (trial) x 2 (time) repeated measures ANOVA, respectively. Blood glucose concentration (mM) was analyzed using a 2 (trial) x 2 (time) repeated measures ANOVA. All ANOVAs were followed with means comparisons. Walking pace was analyzed using a dependent t-test to determine differences across the LM and FST trials.
Chapter Four

RESULTS

Subject Characteristics

The total group (n=3M, 4F) had a mean age of 71.6±5.4 years. All subjects reported regular exercise, consisting of walking at least 3 mornings a week and reported no recent health problems on the medical history questionnaire. The subjects all completed the exercise protocols for both trials. Descriptive data are shown in Table 1.

Measures of Exercise Intensity

The average walking pace was not significantly different for the two trials (78.5±15.2 m/min and 78.1±15.6 m/min for the LM and FST trials respectively). For the variable of RPE, there was no significant interaction between trials, but there was a significant main effect for time (F=33.930, df=3, p<0.05). Means comparisons indicated that there was no significant difference between minutes 0-15 and 15-30. However, RPE was significantly higher in minutes 30-45 (8.786±0.699) and minutes 45-60 (9.357±0.633) when compared to minutes 0-15 (8.000±0.679). No significant interaction or main effects were noted in HR between or within trials. Measures of exercise intensity are shown in Table 2.
**Blood Glucose**

For the variable of blood glucose, the trial x time interaction was significant ($F=7.746$, $df=1,6$, $p<0.05$), see Figure 1. Means comparisons indicated that there were no significant differences pre exercise in blood glucose between the LM ($4.783\pm0.167$) and FST ($4.791\pm0.156$) trials. However blood glucose levels were significantly higher post exercise for the LM trial ($4.837\pm0.154$) compared to the FST trial ($4.711\pm0.198$). There was no significant change in blood glucose within either the FST or LM trials (pre vs. post exercise).

**Balance**

*Sharpened Romberg Test*

For both variables of SR (eyes open and eyes closed), the trial x time interaction was significant ($F=15.538$, $df = 1,6$, $p<0.05$; $F=19.747$, $df=1.6$, $p<0.05$), see Figure 2. Means comparisons for both SR eyes open and SR eyes closed yielded identical results, indicating that there was no significant difference between the LM and FST trial prior to exercise. However, balance for both SR tests was significantly lower post exercise during the FST trial compared to the LM trial. There was no significant change in balance after the LM trial (pre vs. post exercise). However, after the FST trial, balance was significantly reduced compared to the LM trial.

*One Legged Stance Test*

For the variable of OLST eyes open, the trial x time interaction was not significant ($F=6.194$, $df=1,6$, $p=0.0671$). However, the main effect for trial was significant ($F=8.629$,
df=1,6, p<0.05), see Figure 3. OLST eyes open balance was significantly higher during the LM trial (13.143±6.298) compared to the FST trial (9.714±4.730). The main effect for time was also significant (F=6.194, df=1,6, p<0.05). OLST eyes open balance was significantly lower post exercise (10.571±5.880) compared to pre exercise (12.286±5.676). For the variable OLST eyes closed, the trial x time interaction was significant (F=20.680, df=1,6, p<0.05). Means comparisons indicated that there was no significant difference between the LM and FST trials prior to exercise. However, OLST eyes closed balance was significantly lower post exercise during the FST trial compared to the LM trial. There was no significant change in balance after the LM trial (pre vs. post exercise). However, after the FST trial, balance was significantly reduced compared to pre exercise.
Chapter Five

DISCUSSION AND CONCLUSION

Discussion

The primary finding from the current study indicates that the liquid meal (LM), Ensure, is associated with better balance in elderly men and women after moderate exercise. Three out of four of the balance tests showed a significantly greater time in balance for the LM trial when compared to the fasted (FST) trial. The only balance test that resulted in no significant difference between trials was the one-legged stance test (OLST) with eyes open. Although previous research has addressed the effect of long-term exercise programs on balance(5; 12; 37), no known studies have looked at the effects of acute exercise bouts on balance. In addition, to our knowledge no studies have examined the relationship between diet and balance in any population.

Many older individuals eat early dinners, go to bed and exercise before breakfast in the morning. This often translates into exercise sessions following a 10-12 hour fast. Past studies have linked proper nutrition with blood glucose maintenance, increased exercise intensity(27; 28) (29) (30) (31) (32)(33-35), and improved cognitive functioning (20; 21; 24; 25). On the opposite side of this research is the evidence that activity, mental or physical, in a fasted state is compromised. Therefore, the common habit of early morning exercise on an empty stomach can inhibit not only factors such as performance and endurance, as shown in previous studies, but balance can be affected as well. This is particularly important for the elderly due to the high prevalence of injuries and even deaths associated with falls in this population.
Further results from the current study show no significant relationship between consumption of a liquid meal and exercise performance in a morning fasted state, as indicated by RPE, distance walked and HR. These results contradict past research that has linked consumption of a standardized beverage, usually high in carbohydrates, to increased exercise performance and endurance(27; 28) (29) (30) (31) (32)(33-35). It is possible that no significant difference in exercise performance was noted between the LM and FST trials because of the low intensity of exercise. Another possibility that would lead to the discrepancy between my results and those of past studies is that the carbohydrate content of Ensure was insufficient or the distance walked was too short. Subjects could also have influenced each other’s intensities despite the request that they walk alone and at their own self-selected pace.

Conclusion

The purpose of this study was to investigate the relationship between the liquid meal, Ensure, self-selected exercise intensity and balance during moderate exercise in an older population. Results indicate that consuming the liquid meal before exercise can help attenuate declines in balance post exercise in older individuals. The maintenance of balance, especially in the elderly, is particularly important in decreasing the risk of falls, which is one of the most common causes of injuries requiring hospitalization in this population.

Despite the continual encouragement by health professionals across the country to engage in regular physical activity, approximately 70% of the elderly population remain sedentary(4; 6; 7). Many claim that they don’t know how or where to safely exercise and
fear the risk of injury, particularly from falls. If we are to promote regular physical activity for this (or any) population, we must educate them not only on the benefits of exercise, but also on avoiding any associated risks.

According to the results of this study, it is apparent that older populations should be encouraged to eat prior to morning exercise in order to avoid the risk of falling during or after exercise. For a growing older population, who we encourage to maintain healthy lifestyles that include nutrition and exercise, future research is much needed. Such research could include the effects of nutrition on balance throughout the day. Supplementation studies could also be conducted that examine the effects of higher carbohydrate doses on physical performance and balance in older individuals who participate in a variety of exercise or sports activities, especially at higher intensities, for longer duration, or at different times of day.
Tables and Charts

Table 1. Descriptive data of males (n=3) and females (n=4). Expressed as mean ± SD.

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>71.6 ± 5.4</td>
<td>69.7 ± 1.5</td>
<td>73.0 ± 7.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.2 ± 6.7</td>
<td>79.1 ± 2.7</td>
<td>68.7 ± 4.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.2 ± 8.0</td>
<td>177.0 ± 3.9</td>
<td>165.1 ± 6.2</td>
</tr>
<tr>
<td>Time (min)</td>
<td>0-15</td>
<td>15-30</td>
<td>30-45</td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Fasted</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR (b(\text{min}^{-1}))</td>
<td>94.3 ± 8.5</td>
<td>96.0 ± 9.3</td>
<td>96.1 ± 10.3</td>
</tr>
<tr>
<td>RPE</td>
<td>8.0 ± 0.58</td>
<td>8.4 ± 0.54*</td>
<td>8.9 ± 0.69*</td>
</tr>
<tr>
<td><strong>Liquid Meal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR (b(\text{min}^{-1}))</td>
<td>96.6 ± 13.4</td>
<td>95.4 ± 15.0</td>
<td>96.4 ± 12.5</td>
</tr>
<tr>
<td>RPE</td>
<td>8.0 ± 0.82</td>
<td>8.3 ± 0.76*</td>
<td>8.7 ± 0.76*</td>
</tr>
</tbody>
</table>

* Significantly different from time 0-15
Figure 1. Blood Glucose for subject group compared pre and post exercise between FST and LM trials.

Error bars denote SEM
* Significantly different from post-exercise LM trial (p ≤0.05)
Figure 3. Average balance time for the Sharpened Romberg test pre and post exercise with eyes open and closed.

* Significantly different from LM trial (p ≤ 0.05)
† Significantly different from pre-exercise FST (p ≤ 0.05)
Figure 4. Average balance time for the One-Legged Stance test pre and post exercise with eyes open and closed.

* Significantly different from post-exercise LM trial (p ≤ 0.05)
† Significantly different from pre-exercise FST trial (p ≤ 0.05)
Subject Information and Consent Form
Human Performance Laboratory-Dept. of Health and Human Performance
The University of Montana

Title: Effects of carbohydrate on self-selected exercise performance and balance during exercise in a healthy, older population.

Investigators: Leah Paige Versteegen, McGill Hall, 542-9400
Stephen Gaskill, Ph.D., McGill Hall 243-4268
Brent C. Ruby, Ph.D., McGill Hall, 243-2117

Special Instructions to the Potential Subject:
- This consent form may contain words that are unfamiliar to you. Please feel free to ask any questions about the following material.

Purpose:
- You are being asked to participate in a research study examining exercise performance and balance during exercise in response to two feeding trials, one with a carbohydrate beverage and one with a placebo.
- You have been asked to volunteer because you currently participate in regular physical activity, are healthy in accordance with the previously completed questionnaire, and are over the age of 60.
- The purpose of this study is to determine the effects of a carbohydrate beverage on self-selected exercise performance and balance during exercise in a healthy, older population.

Procedures:
If you agree to participate in this research study you will be involved in a preliminary informative session and three exercise testing situations.

The informative session will involve the collection of background and descriptive data and should last no longer than one hour (including some walking). You will be asked to walk two timed standard laps around the mall at a self-selected pace while wearing a heart rate monitor in order to determine your individual heart rate zone and walking speed. In addition, your weight will be measured.

The exercise trials will include 30 minutes of preparation and preliminary testing followed by 1 hour of walking in the mall. The protocols for the exercise sessions will be identical to one another as described below except for the beverage provided. During one of these sessions you will consume a carbohydrate beverage during exercise, while during the other you will consume a placebo.

After an overnight fast (no eating after dinner the previous evening), you will arrive at the mall at 0815. A drop of blood will be collected from a finger prick and a heart rate monitor will be put on for your heart rate to be recorded. Before beginning exercise, you will be given the opportunity to practice the two balance tests three times each. After three practice trials, baseline balance testing will be done: One balance test requires you to maintain balance on one leg, while lifting the other leg only a few inches off the ground. The second balance test is performed in a heel-to-toe standing position with the non-dominant foot forward, once with your eyes open and once with your eyes closed.
Prior to exercise, and midway through, you will receive either a carbohydrate or placebo supplement. Your heart rate will be recorded throughout exercise via a memory feature on the heart rate monitors. A finger prick blood sample will be taken and balance testing will be administered after completing walking at 60 minutes. You blood samples will be used only to measure blood glucose and will not be used for any other purpose. The blood samples will be discarded after the glucose analysis is completed.

Risks/Discomforts:
- All physical activity is accompanied by minimal risk. You should only walk at the speeds that you normally walk during your morning mall walks.
- You will be asked periodically during testing to report any unusual symptoms. Unusual symptoms may include: undue shortness of breath, dizziness, chest/jaw/arm/shoulder/upper back pain, or any discomfort that differs from your normal exercise experience.
- Blood sampling may cause minimal pain, similar to that of a sewing needle stick in the tip of your finger. Slight bleeding and possible bruising may persist after sampling. These risks will be minimized by use of sterile procedures and trained technicians.
- The overnight fast may also cause hunger pains. The beverages provided during exercise may help suppress your appetite, and breakfast will be provided immediately following the exercise trials.
- A risk of falling during the balance testing is present. An attendant will be standing next to you to provide assistance when needed and minimize this risk.

Benefits:
There is no immediate benefit for taking part in this research study. However, your participation may aid health professionals (physicians, nurses, exercise physiologists, cardiac rehab specialists, personal trainers, etc.) in educating older populations on reducing risk of falls during exercise by maintaining blood sugars (glucose) through carbohydrate feedings. It is also possible that older populations can increase exercise intensity and duration through carbohydrate feedings during exercise, thus maximizing the physical and mental benefits they can attain from regular exercise.

Confidentiality:
- Your identity will be kept confidential.
- When the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used.

Compensation of Injury:
- Although we believe that the risk of taking part in this study is minimal, the following liability statement is required in all University of Montana consent forms.

  In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the event of a claim of such injury. Further information may be obtained from the University's Claims representative or University Legal Counsel.

(Reviewed by the University Legal Counsel, July 6, 1993)
Voluntary Participation/Withdrawal:
• Your decision to participate in this research study is entirely voluntary.
• You may withdraw from participation at any time.
• You may be asked to discontinue participation in the study if you fail to follow the instructions of the study director or if the study director believes it is in the best interest of your health and welfare.

Questions:
• If you have any questions concerning this research study contact:
  o Steven Gaskill, Ph. D. (Office: 243-4268, Home: 829-8978)
  o Leah Versteegen (Office: 544-1978, Home: 542-9400)
    at the University of Montana Department of Health and Human Performance.
• If you have any questions regarding your rights as a research subject, you may contact the Institutional Review Board through the Research Office at The University of Montana at 406-243-6670.

Subject Statement of Consent:
I have read and understand the above description of this research study. I have been informed of the risk and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions may be directed to a member of the research team. I voluntarily agree to participate in this study. I understand I will receive a copy of this consent form.

______________________________  ______________________________
Name of subject (print)             Date

______________________________  ______________________________
Subject signature                     Date

______________________________  ______________________________
Signature of witness                   Date
Subject Participation Survey

Name: ________________________________ Phone Number: ______________________

Address: ______________________________

Gender: M  F

Days of the week you typically walk at the mall: Mon  Tue  Wed  Thu  Fri  Sat  Sun

Time spent walking: <30min  30min  1 hour  1½ hours  2 hours  >2 hours

Laps around the mall: ______

I am conducting a study with the Health and Human Performance Laboratory at the University of Montana on the effects of carbohydrates on exercise performance and cognitive function in males and females over the age of 60. This study will take place at the mall over a two-week period during which you will be asked to walk for 2 hours on two separate mornings of your choice. Would you be willing to participate?

Yes  No
American Heart Association and American College of Sport Medicine

PREPARTICIPATION HEALTH SCREENING QUESTIONNAIRE
(HSQ)

Assess your health needs by marking all true statements.

HISTORY
You have had: Subject ID: __________

- A heart attack
- Heart surgery
- Cardiac catheterization
- Coronary angioplasty (PTCA)
- Pacemaker/implantable cardiac defibrillator/rhythm disturbance
- Heart valve disease
- Heart failure
- No exposure to cold therapy (such as slush bucket, ice water, ice packet)
- Heart transplantation
- Congenital heart disease

If you marked any of the statements in this section, consult your healthcare provider before engaging in exercise. You may need to use a facility with a medically qualified Staff.

SYMPTOMS

- you experience chest discomfort with exertion.
- you experience unreasonable breathlessness
- you experience dizziness, fainting, blackouts
- you take heart medications

Other Health Issues

- you have musculoskeletal problems.
- you have concerns about the safety of exercise.
- you take prescription medication(s).
- you are pregnant

CARDIOVASCULAR RISK FACTORS

- you are a woman older than 55 years or you have had a hysterectomy or you are postmenopausal
- you smoke.
- your blood pressure is >140/90
- you don't know your blood pressure.
- you take blood pressure medication
- your blood cholesterol level is >240 mg/dL.
- you don't know your cholesterol level.
- you have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister)
- you are diabetic or take medicine to control your blood sugar.
- you are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).
- you are >20 pounds overweight.

If you marked 2 or more of the statements in this section, consult your healthcare provider before engaging in exercise. You might benefit by using a facility with a professionally qualified exercise staff to guide your exercise program.

None of the above is true.

You should be able to exercise safely without consulting your healthcare provider in almost any facility that meets your exercise program needs.
References


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


