



8-1996

## Effects of Exercise and Psychosocial Stress on Blood Glucose in Non-Insulin Dependent Diabetics

Lisa Renae Clemensen  
*Western Michigan University*

Follow this and additional works at: <https://scholarworks.wmich.edu/dissertations>



Part of the Endocrinology, Diabetes, and Metabolism Commons

---

### Recommended Citation

Clemensen, Lisa Renae, "Effects of Exercise and Psychosocial Stress on Blood Glucose in Non-Insulin Dependent Diabetics" (1996). *Dissertations*. 1692.

<https://scholarworks.wmich.edu/dissertations/1692>

This Dissertation-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Dissertations by an authorized administrator of ScholarWorks at WMU. For more information, please contact [wmu-scholarworks@wmich.edu](mailto:wmu-scholarworks@wmich.edu).



EFFECTS OF EXERCISE AND PSYCHOSOCIAL STRESS ON BLOOD  
GLUCOSE IN NON-INSULIN DEPENDENT DIABETICS

by

Lisa Renae Clemensen

A Dissertation  
Submitted to the  
Faculty of The Graduate College  
in partial fulfillment of the  
requirements for the  
Degree of Doctor of Philosophy  
Department of Psychology

Western Michigan University  
Kalamazoo, Michigan  
August 1996

EFFECTS OF EXERCISE AND PSYCHOSOCIAL STRESS ON BLOOD  
GLUCOSE IN NON-INSULIN DEPENDENT DIABETICS

Lisa Renae Clemensen, Ph.D.

Western Michigan University, 1996

Non-insulin dependent diabetes often has serious consequences for individuals if blood glucose is not maintained within relatively normal ranges. Exercise and stress have been enumerated as important variables for the control of blood glucose in non-insulin dependent diabetics.

This study compared blood glucose and stress for eight exercise and eight matched control non-exercise adult non-insulin dependent participants. A prospective home monitoring design was used to monitor daily blood glucose, stress, and physical activity via multiple measures for six days.

Results indicated that control participants had significantly higher average blood glucose readings and higher blood glucose variability. Daily stress measures did not differ significantly between groups. Although a clear relationship was found between exercise and lowered blood glucose, it is recommended that further examination of the stress-blood glucose relationship be conducted.

## INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

**The quality of this reproduction is dependent upon the quality of the copy submitted.** Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

# UMI

A Bell & Howell Information Company  
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA  
313/761-4700 800/521-0600



**UMI Number: 9703691**

---

**UMI Microform 9703691**  
**Copyright 1996, by UMI Company. All rights reserved.**

**This microform edition is protected against unauthorized  
copying under Title 17, United States Code.**

---

**UMI**  
**300 North Zeeb Road**  
**Ann Arbor, MI 48103**

## ACKNOWLEDGMENTS

How do I begin to thank those that have supported and assisted me with this most difficult endeavor? I will begin with a special thanks to Dr. Michele Burnette, who has fostered my professional and personal development more than anyone. I cannot count the endless hours she has been available for me, constantly guiding, challenging, and most importantly, always listening. I also would like to extend my sincere appreciation to Dr. Virginia Goetsch, who made this research possible and who graciously accepted me in West Virginia as if I were one of her own students. My committee members, Dr. Richard Spates, Dr. Lisa Baker, and Dr. Galen Alessi also deserve appreciative mention.

Second, my mother, father, sister, and brother deserve careful mention and earnest appreciation for their constant love, encouragement, guidance, and support. Without their assistance, this would never have been possible.

Finally, I would like to thank my Minnesota friends, Chris, Denise, Deanna, Michelle, and Jill, who have continued to believe in me in spite of my own doubts. My roommate and friend, Mari, friend, C.J., and Tim require special attention, as they have been through the

### Acknowledgments-Continued

good and bad with me and have provided me with the additional revitalizing energy that was necessary to complete this project. To all those mentioned, I dedicate this dissertation.

Lisa Renae Clemensen



## TABLE OF CONTENTS

ACKNOWLEDGMENTS.....	ii
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
INTRODUCTION.....	1
Statement of the Problem.....	1
Rationale.....	2
REVIEW OF RELATED LITERATURE.....	3
Stress and Control of Diabetes.....	8
Impact of Exercise on Diabetes.....	15
Purpose of the Study.....	21
METHOD.....	24
Participants.....	24
Materials.....	25
Design and Procedure.....	28
Training Session.....	28
Home Monitoring.....	29
Final Session .....	30
Scoring.....	31
RESULTS.....	34
Preliminary Analyses.....	34
Primary Analyses.....	34
Demographic Variables.....	35

## Table of Contents-Continued

Nutrient Intake.....	37
Blood Glucose and Stress.....	38
Comparisons of Stress by Group.....	39
Comparisons of Blood Glucose by Group.....	43
Activity.....	45
Summary.....	48
DISCUSSION.....	50
Limitations.....	54
Future Directions.....	57
APPENDICES	
A. Protocol Clearance From the Human Subjects Institutional Review Board.....	60
B. Demographic Questionnaire.....	66
C. Diet Monitoring Log.....	68
D. Blood Glucose and SUDS Monitoring Form.....	71
E. Physical Activity Scale for the Elderly.....	73
F. Informed Consent.....	76
G. Dietary Training Instructions.....	81
H. Blood Glucose Training Form.....	83
I. Pedometer Training Instruction Form.....	85
J. Daily Reminder Sheet.....	87
BIBLIOGRAPHY.....	89

## LIST OF TABLES

1. Demographic Variables.....	35
2. Matching Variables.....	37
3. Average BG Rating Compared on High and Low Stress Days.....	38
4. Correlations of Average Daily BG and Average Daily SUDS Ratings.....	40
5. Composite Stress Ratings for Four Stress Measures.....	40
6. Average Stress Ratings for Four Stress Measures.....	41
7. Diabetic Daily Hassle Averages.....	42
8. Average BG Ratings Comparing Exercise and Control Groups.....	44
9. Pearson Correlation Coefficients Activity and Stress.....	45
10. Comparison of Means (in Minutes) for Household Activities, Leisure Activities, and Active Minutes From the PASE.....	46
11. Average Pedometer Readings (Number of Steps) Comparing Exercise and Control Groups.....	47
12. Average Number of Work Minutes Comparing Exercise and Control Groups.....	48

## LIST OF FIGURES

1. Average Blood Glucose on High Versus Low Stress Days.....	39
2. Average Blood Glucose Ratings for Exercise and Control Participants.....	44

## INTRODUCTION

### Statement of the Problem

Diabetes mellitus affects many individuals, and can have numerous adverse consequences if blood glucose is not maintained in relatively normative ranges. The diabetic regimen required to control blood glucose is complex and difficult to manage for many diabetics. Moreover, the precise blood glucose values necessary to lower the risk of complications are not yet known (Skyler, 1987).

In addition to the diabetic regimen, exercise and stress have been enumerated to be important in the control of blood glucose. Exercise was noted to substantially lower blood glucose as early as the late 1920's (Lawrence, 1926), and benefits of exercise on glucose metabolism, insulin action, and cardiovascular risk factors have been shown since that time.

Research focusing on stress and its effects on blood glucose have proven to be much more equivocal. Overall, results have shown some positive effects, but differences in methodology and individual responses to stress have confounded the results.

## Rationale

This study proposed to expand on previous research and examine the relationship between exercise, stress, and blood glucose. Non-insulin dependent diabetics were used, as research has shown a more consistent positive effect of exercise with this population. Research related to stress and blood glucose has also shown a more concordant relationship using this population. Second, a matched control group was used to compare the differences between exercise and non-exercise groups. Finally, a home monitoring procedure was utilized to examine the effects of exercise and stress on blood glucose in the natural environment.

The purpose of this study was to compare stress ratings, blood glucose, and activity levels between an exercise and a non-exercise control group. This study should be seen as a preliminary study in adding to the stress-blood glucose literature base and concluding with specific directions for future research.

## REVIEW OF RELATED LITERATURE

Diabetes mellitus is a metabolic disease characterized primarily by chronic hyperglycemia, currently affecting more than ten million Americans (Surwit, Feinglos, & Scovern, 1983; U.S. Department of Health and Human Services, 1985). There are two distinct types of diabetes, insulin-dependent (Type I or juvenile-onset) and non-insulin-dependent (Type II or adult-onset) diabetes. Insulin-dependent diabetes mellitus (IDDM) frequently occurs in early childhood. It is thought to be triggered by a viral infection which destroys most or all of the insulin-producing beta cells in the pancreas in genetically predisposed individuals (Craighead, 1978; Palmer & McCulloch, 1991). IDDM is therefore characterized by an inability to produce sufficient insulin and single or multiple daily insulin injections must be administered.

The etiology of non-insulin-dependent diabetes mellitus (NIDDM) is less clear than that of IDDM. It appears a certain susceptibility to different environmental factors exists which triggers the onset of NIDDM in predisposed persons. One of these factors is an overabundance of food intake which results in elevated levels of insulin production and, therefore, increased insulin resistance.

Over-exposure of the cells to insulin, and insulin deficiency, causes the pancreas to become damaged or exhausted from overproduction (Pohl, Gonder-Frederick, & Cox, 1984). NIDDM primarily occurs after age 40 and is the most common form of diabetes. Rather than insufficient insulin production as in IDDM, NIDDM is distinguished by normal or even elevated levels of insulin. However, the peripheral cells demonstrate resistance to glucose, and therefore make glucose more difficult to metabolize (DeFronzo, Bonadonna, & Ferrannini, 1992).

Diabetes mellitus often has serious consequences for persons suffering from the disorder. Pohl, Gonder-Frederick, and Cox (1984) and Surwit, Feinglos, and Scovern (1983) describe the process whereby the chronic hyperglycemia typical of diabetes mellitus leads to serious health complications. Individuals with diabetes mellitus suffer from a defect in insulin secretion or action which interferes with the cell membrane's permeability to glucose. Therefore, glucose cannot be used by the cells of the body, and glycogen, fat, and protein are instead metabolized for energy. Although some glucose is released via urine excretion, excess glucose accumulates in the bloodstream. This interruption in normal metabolism can result in fatigue, weight loss, and dehydration, leading to



either hyperosmolar coma or ketoacidosis, and potentially death if left untreated.

Even individuals with moderately elevated glucose levels are at risk for retinopathy, nephropathy, neuropathy, blindness, lower limb amputations, and a number of life-threatening diseases including coronary heart disease and stroke (Keen & Jarrett, 1982; National Center for Health Statistics, 1980; Skyler, 1987). The serious consequences of the disease often lead to lower quality of living as well as to anxiety and depression (Lloyd, Matthews, Wing, & Orchard, 1992; Wredling, Theorell, Roll, Lins, & Adamson, 1992).

It is possible that the aforementioned complications of diabetes mellitus can be interrupted or potentially prevented by maintaining blood glucose (BG) within a relatively normal range (Knuman, Welborn, McCann, Stanton, & Constable, 1986; Skyler, 1987). Skyler (1987) discussed epidemiological studies which have found correlations between degree of hyperglycemia and frequency, severity, and rate of progression of complications. Clinical studies have been more equivocal, most likely because some diabetic patients are more prone to complications than others, presumably because of genetics and behavioral characteristics (e.g. smoking). Most of the studies involved small numbers of participants followed for short durations. The Diabetes

Control and Complications Trial (DCCT) was a seven year study which showed that intensive therapy (normalization of blood glucose) compared to standard treatment (goal being clinical well-being) reduced the risk for diabetic retinopathy, nephropathy, and neuropathy by 60% in IDDM (Crofford, 1995; DCCT, 1993). Therefore, intensive treatment of diabetes can reduce the onset and progression of various diabetic complications. Although this study was conducted with Type I diabetics, it has important implications for the treatment of Type II diabetes as well.

Control of BG can be accomplished via a complex and precise program of dietary restriction, exercise, self-monitoring of blood or urine glucose, and the use of insulin and/or oral medications. Because of the multiplicity of behavioral changes necessitated, adherence to the diabetic regimen is often poor. In studies of compliance, NIDDM and IDDM patients are often studied simultaneously, and distinguishing characteristics between the two groups have not been recognized. Also, studies primarily focus on IDDM participants. For both populations, adherence to medication prescriptions is higher than dietary and exercise compliance (Ary, Toobert, Wilson, & Glasgow, 1986; Cox, Taylor, Nowacek, Holley-Wilcox, Pohl, & Guthrow, 1984; Glasgow, McCaul, & Schafer, 1984; Shlenk & Hart, 1984), while there is much variability regarding

urine or blood glucose testing (Bennett-Johnson, 1992). Possible predictors of adherence are age of participant, time since diagnosis, complexity of behavioral regimen, and additional complications of the diabetes. However, none have been identified as singly or collectively predictive (Bennett-Johnson, 1992).

Although the diabetic regimen is important for maintaining a diabetic's blood glucose at appropriate levels, a patient's metabolic status is not an appropriate indicator of adherence. A direct correspondence between metabolic control and adherence has not been found in the literature (Glasgow, McCaul, & Schafer, 1987; Glasgow, Toobert, Riddle, Donnelly, Mitchell, & Calder, 1989; Johnson, 1990; Johnson, Freund, Silverstein, Hansen, & Malone, 1990). This lack of a direct one-to-one relationship seems to be the result of adherence being important to metabolic functioning in addition to other factors including "appropriateness of the prescribed regimen, duration of disease, presence of other illness conditions, hormonal changes associated with growth and development, and heredity, to name a few" (Johnson, 1992, p. 1661). Another consistent finding is that adherence to one aspect of the diabetic regimen is not indicative of adherence to other aspects. Therefore, Bennett-Johnson (1992) recommends measuring adherence over time via each individual component (diet,

exercise, glucose and/or urine testing, medication usage) and not relying on blood glucose or other metabolic indices.

### Stress and Control of Diabetes

In addition to the diabetic self-regimen, psychological stress has been found to be related to fluctuations in blood glucose in some individuals with diabetes (Goetsch, 1989). Moreover, diabetics perceive stress as an important modulator of their blood glucose (Cox, Taylor, Nowacek, Holley-Wilcox, Pohl, & Guthrow, 1984). Stress may also be related to the development of diabetes. A study by Robinson and Fuller (1985) found a higher number of severe life events in IDDM participant's history compared to siblings and matched controls.

Stress may affect diabetics indirectly, as when it interferes with the diabetic regimen in vulnerable and fatigued individuals (Marlatt & Gordon, 1985), or directly, as when stress causes physiological changes such as increased cortical activity, heart rate, blood pressure, and sweating (Cannon, 1941). Other physiological alterations during the stress period include the release of epinephrine and cortisol from the adrenal glands (Bliss, Migcon, Branch, & Samuels, 1956; Levi, 1972). When these hormones are released, other modifications such as the release of glucagon

into the bloodstream, inhibited insulin release, and increased insulin resistance all contribute to an increase of glucose in the bloodstream. These responses occur in order to prepare the body for "fight" or "flight" and provide it with more energy reserves, but these changes can be quite detrimental for the diabetic if chronic hyperglycemia results.

Numerous researchers have attempted to elucidate more fully the relationship between stress and blood glucose via chemical infusion studies (e.g. Gerich, Lorenzi, Tsalikian, & Karen, 1976; Shamoon, Hendler, & Sherwin, 1980), retrospective studies examining naturally occurring stressful events (e.g. Chase & Jackson, 1981; Cox, Taylor, Nowacek, Holley-Wilcox), or by experimentally introducing a stressor and examining the resultant effects on blood glucose (e.g. Goetsch, VanDorsten, Pbert, Ullrich, & Yeater, 1993; Surwit, Feinglos, Livingston, Kuhn, & McCubbin, 1984). Studies with animals have found a consistent connection between stress and hyperglycemia (Kuhn, Cochrane, Feinglos, & Surwit, 1987; McCubbin, Surwit, Kuhn, Cochrane, & Feinglos, 1987; Surwit, Feinglos, Livingston, Kuhn, & McCubbin, 1984) as well as development of the disease contingent on the presence of multiple stressors (Carter, Herrman, Stokes, & Cox, 1987). Human studies using infusion of stress hormones have also consistently found a hyperglycemic and

hypoinsulinemic effect (Gerich, Lorenzi, Tsalikian, & Karam, 1976; Shamoon, Hendler, & Sherwin, 1980). Therefore, there has been found a consistent positive relationship between physical and psychological stress and blood glucose in animals and between physical stressors and hyperglycemia in humans. Conversely, there is less research and less consistent findings regarding the psychological stress-blood glucose association in humans (Wing, Epstein, Blaire, & Nowalk, 1985)

Goetsch (1989) and Goetsch and Wiebe (1994) reviewed the literature regarding the influence of stress on blood glucose and derived interesting conclusions. The authors noted that human studies using psychological stress as an independent variable do not find overwhelmingly support for a positive relationship between blood glucose and stressful events. Laboratory paradigms have been attempted using artificial stressors to elicit the "fight" or "flight" response. These studies have yielded inconsistent results, with findings of hyperglycemia (Cox, Gonder-Frederick, Clarke, & Carter, 1988; Goetsch, VanDorsten, Pbert, Ullrich, & Yeater, 1993; Goetsch, Wiebe, Veltum, & VanDorsten, 1990), hypoglycemia (Vandenbergh, Sussman, & Titus, 1966; Vandenbergh, Sussman, & Vaughn, 1967), or nonsignificant effects on blood glucose in IDDM, NIDDM, and nondiabetic participants (Carter, Gonder-Frederick, Cox, Clarke, &

Scott, 1985; Edwards & Yates, 1985; Hinkle, & Wolf, 1952a; Hinkle, & Wolf, 1952b; Kemmer, Bisping, Steingruber, Baar, Hardtmann, Schlaghecke, & Berger, 1984; Naliboff, Cohen, & Sowers, 1985).

Although it appears that these results provide evidence against a stress-glucose relationship, the inconsistencies may result from differences in methodology between studies and variations in individual responses to stress. Goetsch (1989) identified methodological limitations of the aforementioned studies to be differences in number and type of stressor, dependent variable measurement times, and lack of external validity of each stressor. Other limitations of the studies included small sample sizes, studying Type I and Type II diabetics concurrently, and using non-standardized stressors (Wing, Epstein, Blaire, & Nowalk, 1985). Another potential limitation of prior studies may be variability between time of blood sample collections, as one study found that the peak glucose response was delayed up to 30 minutes following the introduction of a standardized stressor in non-diabetic participants (Wing, Epstein, Blair, & Nowalk, 1985).

In summary, laboratory data with humans do support the contention that psychological stress affects blood glucose in some cases, but because of methodological and individual differences, results have not been consistent. Also, it is

not currently possible to generalize findings to the natural environment, although one study did find external validity for the laboratory paradigm (Goetsch, et al., 1993).

Moving the study of stress and blood glucose into the natural environment with humans is a logical extension of the research that has been conducted. Again, these studies report incongruous results, with some authors reporting positive relationships between stress and glycosylated hemoglobin, which is an index of blood glucose over the last three to four months, (Chase & Jackson, 1981; Cox, Taylor, Nowacek, Holley-Wilcox, Pohl, & Guthrow, 1984; Robinson & Fuller, 1985; Schwartz, Springer, Flaherty, & Kiani, 1986) and between stress and blood glucose (Goetsch et al., 1990), while others found no relationship (Delamater, Kurtz, Bubb, White, & Santiago, 1987; Halford, Cuddihy, & Mortimer, 1990; Wilson, Ary, Biglan, Glasgow, Toobert, & Campbell, 1986).

Therefore, the literature does lend support to the hypothesis that stress affects blood glucose in persons with diabetes, but the specific mechanisms have not yet been identified. Because of the lack of control possible in the natural environment and the divergent definitions of life stress, it is not surprising to find these discrepancies, and therefore, conclusions are difficult to



generate. There is a need for more controlled and clearly defined studies of the stress-blood glucose relationship in the natural environment.

A home-monitoring procedure whereby participants monitor blood glucose and daily stressors using multiple measures can accomplish the preceding goals. Goetsch & Wiebe (1994) reported on three home monitoring studies with IDDM which have been conducted (Aikens, Wallander, Bell, & Cole, 1992; Halford, Cuddihy, & Mortimer, 1990; Hanson & Pichert, 1986). All three found a positive relationship between stress and hyperglycemia, and this association was purported to be due to the direct effects of stress rather than indirect because the relationship occurred independent of adherence to the diabetic regimen. Goetsch et al. (1990) conducted the only home-monitoring study with NIDDM participants which also supported this positive relationship.

A final alternative method of examining the stress-glucose relationship is by studying the effects of stress management techniques. Relaxation training has proven useful in controlling blood glucose in NIDDM participants (Lammers, Naliboff, & Straatmeyer, 1984; Surwit, & Feinglos 1983a; Surwit, & Feinglos, 1983b), while inconsistent results have been shown with IDDM participants (Bradley, Moses, Gansu, Knight, & Ward, 1985; Feinglos, Hastedt, &

Surwit, 1987; Landis, Jovanovic, Landis, Peterson, Groshen, Johnson, & Miller, 1985). From these naturalistic studies and relaxation procedure studies, it appears that there is a more concordant stress-glucose relationship in NIDDM compared to IDDM participants (Goetsch, et al., 1990; Goetsch, et al., 1993; Lammers, Naliboff, & Straatmeyer, 1984; Surwit & Feinglos 1983a; Surwit, & Feinglos, 1983b), and research with NIDDM participants may more clearly delineate the mechanisms by which stress modifies blood glucose.

Surwit and Feinglos (1988) provided further evidence for this hypothesis. They reviewed the literature related to stress and diabetes and found evidence for "...altered sympathetic nervous system activity in type II diabetes (p. 83)," especially increased peripheral catecholamine responsivity. The authors suggested that because psychological and physical stress stimulate this autonomic nervous system, it follows that those with NIDDM will be more susceptible to stress.

In conclusion, it appears that controlled laboratory studies with animals and chemical infusion studies with humans support a positive relationship between stress and blood glucose, as do naturalistic home-monitoring and a few relaxation procedures with NIDDM participants. Conversely, laboratory stress-induction and retrospective studies of

major life events with IDDM and NIDDM participants have produced equivocal results. Methodological problems and individual differences in physiological reactivity to stressors may account for those inconsistencies in the literature.

### Impact of Exercise on Diabetes

Exercise has been enumerated as an important component of the diabetic self-management regimen and has been found to be useful in combination with diet, especially with NIDDM patients (Wing, Epstein, Paternostro-Bayles, Kriska, Nowalk, & Gooding, 1988). The 1991 position statement of the American Diabetes Association on Diabetes Mellitus and Exercise (Diabetes Mellitus and Exercise, 1991) recommended exercise as an adjunctive therapy for individuals with NIDDM to improve physiological and psychological well-being. The 1992 position statement of the International Society of Sport Psychology stated that "From the clinical perspective, there is evidence that exercise can beneficially affect hypertension, osteoporosis, adult-onset diabetes, and some psychiatric disorders" (Physical activity and psychological benefits: A position statement from the International Society of Sport Psychology, 1992, p. 94). Also, Leon, Connett, Jacobs, and Rauramara (1987) found that increased physical activity reduced the risk of

coronary heart disease in non-diabetic individuals. These numerous sources support and recommend exercise for NIDDM diabetics.

Diabetic and non-diabetic individuals respond differently to exercise. During exercise, the muscles use stored glycogen until the supply is depleted, and then glucose from the liver is utilized for energy. Because the muscles require more glucose during exercise, there is a corresponding increase in glucose production to prevent hypoglycemia. Despite this increased production, the level of glucose concentration in the bloodstream in non-diabetics remains constant (Felig & Wahren, 1975; Zinman, 1984). Conversely, fuel homeostasis and blood glucose levels are not maintained as readily with diabetic persons. This occurs because of decreased insulin secretion (IDDM participants) and increased production of catecholamines, glucagon, growth hormone, and cortisol in both NIDDM and IDDM (Wasserman, Lickley, & Vranic, 1983). Because insulin, glucose, and the counter-regulatory hormones are largely involved during exercise, people with IDDM and NIDDM diabetes respond differently than non-diabetics (Zinman, Murray, Vranic, Albisser, Marliss, 1977 as cited in Zinman, 1984; Zinman, Vranic, Albisser, & Marliss, 1979 as cited in Zinman, 1984).

Exercise was initially demonstrated to substantially lower glucose in the late 1920's (Lawrence, 1926). The benefits of this attenuation have been exhibited more consistently in NIDDM than in IDDM participants, mainly because there is a greater risk in IDDM individuals to develop hypoglycemia during or after exercise. Also, because of increased peripheral catecholamine responsivity (Surwit & Feinglos, 1988), aerobic conditioning may be particularly beneficial for NIDDM patients. Exercise has been found to increase peripheral insulin sensitivity and fitness in IDDM participants, but long term improvements in glucose metabolism in IDDM humans have not been shown to date (Wallberg-Henriksson, Gunnarsson, Henriksson, DeFronzo, Felig, Ostran, & Wahren, 1982; Zinman, Zuniga-Guajardo, & Kelly, 1984). Wallberg-Henriksson (1989) suggested that for IDDM patients, diet and insulin may need to be modified concurrently with an exercise program to improve blood glucose control.

Despite the inconsistencies found with IDDM participants, studies with NIDDM participants have found that regular exercise has resulted in improvements in glucose tolerance in as little as seven days (Rogers, Yamamoto, King, Hagberg, Ehsani, & Holloszy, 1988), and improvements in glucose metabolism, insulin-induced glucose disposal, insulin action, fasting plasma glucose levels, and reduced

cardiovascular risk factors have been found with longer exercise programs (DeFronzo, Ferrannini, & Koivisto, 1983; Reitman, Vasquez, Klimes, & Nagulesparan, 1984; Ruderman, Gauda, & Johansen, 1979; Schneider, Amorosa, Khachadurian, & Ruderman, 1984; Trovati, Carta, Cavalot, Vitali, Banaudi, Lucchina, Fiocchi, Emanuelli, & Lenti, 1984; Wing, et al., 1988; Yeater, Ullrich, Maxwell, & Goetsch, 1990).

Other findings have been lowered maximal oxygen uptake, decreased resting and exercise blood pressure, improved glycosylated hemoglobin levels, and improved plasma triglycerides for a more long term (3 month) exercise program. These gains were maintained at one year for participants who remained in the program (Schneider, Khachadurian, Amorosa, Clemow, & Ruderman, 1992). Another long term study (one year) found increased maximal oxygen uptake, improved insulin sensitivity, and normalized glucose response (Holloszy, Schultz, Kusnierkiewicz, Hagberg, & Ehsani, 1986).

In addition to previously mentioned benefits, studies of exercise with NIDDM participants have found reductions of triglycerides, low density lipoproteins, casual blood pressure and heart rate, and increases in high density lipoproteins (Vitug, Schneider, Rueman, 1988; Wood & Haskell, 1979; Yeater et al., 1990). Although the processes whereby improvements occur have not been delineated,

researchers have proposed increases in the number, sensitivity, and binding capacity of insulin receptors as possible mechanisms (Crews and Landers, 1987). Again, the majority of the studies regarding exercise and NIDDM participants have studied the short-term effects of exercise, and long term effects remain to be enumerated.

Exercise increases caloric expenditure, thereby aiding in fat loss and weight control. Also, obesity has been shown to be related to insulin resistance (Steiner, 1981). Therefore, if exercise reduces total body fat and, hence, obesity, it would appear that improved insulin functioning would result. Because NIDDM is characterized by obesity, a relative lack of insulin, and peripheral insulin resistance, it follows that physical activity, which increases insulin sensitivity and aids in fat loss, will be especially beneficial for NIDDM participants. All of the aforementioned benefits of exercise can potentially modify the serious consequences of diabetes in NIDDM participants.

In addition to the physical effects of exercise, there appear to be physiological and psychological benefits. For both diabetics and non-diabetics, improvements in subjective mood states, including depression, have been found (Bahrke, & Morgan, 1978; Maynard, 1991; Morgan, 1985; Morgan, Roberts, Brand, & Feinerman, 1970). Also, aerobic exercise has been found to attenuate epinephrine and car-

diovascular responses to environmental stress and to improve subjective mood states in non-diabetic populations (Blumenthal, Emery, Walsh, Cox, Kuhn, Williams, & Williams, 1988; Crews & Landers, 1987).

A meta-analysis by Crews and Landers (1987) regarding aerobic fitness and reactivity to psychosocial stressors found that exercise attenuated stress especially well in middle-aged and older adults who were primarily sedentary. These findings generalize well to a population of NIDDM participants, who are quite similar with respect to those characteristics. The authors also found that non-diabetic participants who were aerobically fit showed an increased resistance to psychosocial stress compared to baseline and control participants. This attenuation was thought to be because "reduced physiological response to stress or faster physiological recovery results in overall less time spent in stress at perhaps a lower level of stress" (Crews & Landers, 1987, p. S118).

Regarding studies with diabetic participants, one study (NIDDM) has shown that aerobic training increased participants resistance to the physiological effects of psychological stress (Goetsch, Pbert, VanDorsten, & Yeater, 1988). Conversely, findings of small or no differences in response to laboratory stressors following aerobic conditioning have been reported (Clayton, Cox, Howley, Lawler,



& Lawler, 1988; Hull, Young, & Ziegler, 1984; Sinyor, Golden, Steiner, & Seraganian, 1986; Sothman, Horn, Hart, & Gustafson, 1987). Because there is a paucity of research related to the relationship between exercise and stress in diabetics, firm conclusions cannot be made.

In summary, aerobic exercise has been demonstrated to have beneficial physical, physiological, and psychological consequences for diabetics, with more consistent positive effects found with NIDDM participants. Moreover, NIDDM participants have multiple coronary heart disease risk factors and are often obese. Exercise may therefore provide further benefits for this population as it has been shown to reduce coronary heart disease factors, decrease body fat, improve metabolic parameters, and potentially function as a stress management technique. Negative outcomes obtained from laboratory studies do not generalize to naturalistic studies and in spite of negative findings, it appears that aerobic exercise has great potential for reducing participants' responses to stress, especially with NIDDM participants.

#### Purpose of the Study

The purpose of this study was to further evaluate the effects of aerobic conditioning on stress and blood glucose in NIDDM adults. Participants were enrolled in either a

traditional aerobic conditioning or a water aerobic conditioning program, or were in a non-exercising control group. Beneficial effects of aerobic exercise have been detected in studies utilizing NIDDM with as little as six (Reitman, Vasquez, Klimes, & Nagulesparan, 1984) and eight (Goetsch, Pbert, VanDorsten, & Yeater, 1988) participants per condition. Sixteen participants were involved in a seven day home monitoring assessment period for this study.

Because the stress "buffering" effects of aerobic conditioning have only recently been studied, this study also proposed further to examine the effects of an aerobic conditioning program on psychological stress caused by environmental stressors. The use of a control group allowed for examination of aerobically fit individuals compared to those who were sedentary.

This study aimed further to evaluate the stress-glucose relationship, which is still poorly understood. It does appear that stress has more consistent effects with NIDDM compared to IDDM, but further research is necessary to delineate the direction of this relationship. Home monitoring appears to be a viable means of studying this relationship, and previous studies (only one with NIDDM participants) have found a positive relationship.

Based on the literature review, the following null hypotheses were generated:

1. Blood glucose will be higher on high stress days compared to low stress days.
2. Participants in aerobic conditioning programs will have lower stress ratings compared to controls.
3. Participants in aerobic conditioning programs will have lower blood glucose readings compared to controls.

## METHOD

### Participants

Sixteen adults, ages 44-74 and diagnosed with non-insulin dependent diabetes (NIDDM), participated in the study. Participants were six females and two males in the exercise group and five females and three males in the control group.

Participants were recruited through a water aerobic program, traditional land aerobic program, and via flyers placed in diabetic and family medicine clinics. The researcher also recruited two days a week at a local diabetic clinic. Approximately 86 persons were contacted, including the 16 that participated, and 70 that were excluded because they refused to participate, did not meet research criteria, and/or were a poor match based on group matching variables. Potential participants were also excluded for the following reasons: (a) taking insulin or other medications known to affect blood pressure or catecholamines (e.g., beta blockers, etc.); (b) significant renal disease, cardiovascular disease, or autonomic neuropathy; (c) dementia or psychological disorder (e.g., psychosis) that would affect participation; or (d) musculoskeletal disorder that would prohibit exercise.

The eight participants in the exercise group had been exercising the previous 16 weeks for at least three days per week with at least an 80% compliance rate. The eight participants in the control group were not in any formal or informal exercise program. Three of the eight participants in the exercise condition were chosen from a sample enrolled in a water aerobic program, and five of the eight participants in the exercise condition were chosen from a traditional land aerobic program. The water aerobic program was at Mountainview Regional Rehabilitation Hospital and consisted of 5-10 minutes of warm-up and flexibility exercises followed by an aerobic workout for 40-45 minutes at 70-80% of maximal heart rate, followed by 5-10 minutes of cool-down exercises. The land aerobic program was held at the West Virginia University Coliseum and consisted of 5-10 minutes of warm-up and flexibility exercises followed by walking for 45 minutes at 70-80% of maximal heart rate, and then 5-10 minutes of cool-down exercises.

### Materials

Demographic and matching variables were collected using three devices. The first was a structured demographic questionnaire comprised of the following variables: age, gender, education level, marital status, diabetic diagnosis, years since diagnosis, age of diag-

nosis, aerobic conditioning program, and medical history (Appendix B). The second was through the attainment of heights and weights measured via the same height/weight scale for all participants. Finally, a blood sample was drawn by a nurse to calculate a measure of glycosylated hemoglobin (Hgb A-1C), which is an index of blood glucose over the last three to four months that remains consistent over time (Goetsch & Wiebe, 1994). The Hgb A-1C results for all participants were calculated in a uniform laboratory by the same technician.

Participants were trained to measure food and liquid intake using the Health-O-Meter scale, a device which weighs food in ounces. Dietary data were collected by participants via a structured form (Appendix C), and the Pfizer Minipress Dietrak program was used to calculate percentages of caloric intake from protein, carbohydrate, fat, fiber, cholesterol, and sodium.

A Lifescan digital glucometer equipped with memory was used to measure blood glucose, and participants recorded the results on a structured form (Appendix D). The Lifescan One Touch has been found to be one of the most accurate blood glucose monitors with "reliable readings within 10 to 15% of the reference value over the entire range of 83-620 mg/dl, respectively" (Blood Glucose Monitors, 1988, p. 255).

Two self-report measures were used to collect subjective stress ratings. The first was a daily "subjective units of distress scale" (SUDS; Appendix D). This measure involved rating stress on a continuum with 0 = "not at all stressed" and 10 = "extremely stressed". The second stress measure was the Daily Stress Inventory (DSI). The DSI yielded three scores; an Event score, an Impact score, and an Impact/Event Ratio score. The Event score indicated the frequency of stressful events occurring throughout the day. The Impact score involved rating the severity of each stressor on a continuum with 1 = "occurred but was not stressful", and 7 = "caused me to panic". The Impact/Event Ratio score was the severity of all stressors divided by the total frequency of stressors for each day. Brantley and Jones (1993) reported high internal consistency indices for Event and Impact scores (.83, .87, respectively) and convergent validity with endocrine measures of stress and subjective ratings of stress with Impact scores and Impact/Event Ratio scores. Also, they obtained concurrent validity with the Diabetic Daily Hassles Scale and divergent validity with measures of pleasant events, social desirability, and hostility.

One mechanical device and one self-report measure was used to measure total activity for each participant. An Omron pedometer equipped with memory was used, which was a

device worn on the waist-band of pants that automatically measured and stored distance traveled. The physical activity scale for the elderly (PASE; modified to measure daily activity; Appendix E) was a self-report measure that evaluated the frequency and intensity of daily physical activity. Washburn, Smith, Jette, and Janney (1992) reported that the PASE had convergent validity with health status, strength, and balance and had a test-retest reliability coefficient (0.75) that was larger than other physical activity scales.

### Design and Procedure

#### Training Session

After participants had agreed to be in the study, a training session was scheduled. During the training session, all demographic information was collected and all training was conducted. After signing an informed consent (Appendix F), participants completed a structured demographic questionnaire and participants' heights and weights were measured. Blood samples were also collected at this time.

Participants were instructed on how to measure, weigh, and record their dietary intake (Appendix G). This consisted of providing participants with an example of one ounce of carrots and then requiring them to accurately est-



imate the weight of other foods (carrots, potatoes, rice crispies, and water) within  $\pm .5$  ounce using the Health-O-Meter scale. This was conducted until participants estimated 3 items in a row correctly. A Health-O-Meter scale was given to participants if they did not have a food scale at home.

Second, participants received instruction on recording blood glucose (BG) levels via a Lifescan digital glucometer (Appendix H). A 5% reliability criterion for three successive trials was used during training and the average number of trials for all 16 participants was 3.38 (SD = 1.15). Participants also received instruction on using the Subjective Units of Distress Scale (SUDS) and the Daily Stress Inventory (DSI).

Finally, participants were instructed on placement and use of a digital pedometer (Appendix I). They received training until they were able to record with 100% accuracy (with a .05 error rate). Participants were also introduced to the Physical Activity Scale for the Elderly (PASE).

#### Home Monitoring

Participants self-monitored their diet, exercise, blood glucose, and stress every other day for seven days, with at least one weekend day included. Therefore, data collection lasted for a two week period. Participants in

the exercise group collected data only on the days they were not exercising in their formal exercise classes (e.g. Tuesday, Thursday, and Saturday) and control participants followed the same procedure. The first day of data collection was not included in the statistical analysis to control for reactivity. The researcher provided each participant with a daily reminder sheet (Appendix J) and prompted them the first two evenings before days two and three of self-monitoring.

Participants recorded their dietary intake, including all foods and liquids ingested, on a self-monitoring form for the first three days of monitoring. Participants were then asked to repeat foods and liquids ingested from the first three days of monitoring on the last three days of monitoring.

Participants rated their current stress on a 10-point SUDS scale before they measured their BG four times a day. Both SUDS ratings and BG readings were taken immediately prior to breakfast, lunch, dinner, and bedtime. The Daily Stress Inventory and the Physical Activity Scale for the Elderly were completed at the end of each day.

### Final Session

After participants had fully completed data collection, they returned for a feedback session. During this

session, the researcher verified all BG measurements by comparing the written measurements to the results on the BG monitor, checked all questionnaires for completeness, and answered any questions. They were then paid \$25 for their participation.

### Scoring

Body Mass Index (BMI) was calculated by using the scale developed by Bray (1978). Height and weight measures were used to calculate BMI and these data were summarized into the BMI categories of obese, overweight, and acceptable.

Because of poor compliance to repeating their diet on the final three days of monitoring, an "adequacy variable" was created for two days of data for each participant. This variable was based on the American Diabetes Association (ADA) recommendations for the following nutrients: cholesterol, fat, fiber, sodium, protein, and carbohydrates. Participants therefore received a numerical score of 1 if they met or were below the recommendations, or a numerical score of 2 if they were above the ADA recommendations.

Stress was examined by taking the highest and lowest stress days from daily SUDS, Daily Stress Inventory-Event score, Daily Stress Inventory-Impact score, and Daily

Stress Inventory-Ratio score and using the corresponding BG. If more than one high or low stress rating existed, an average of the corresponding BG was calculated. Therefore, each of the four above-mentioned measures yielded a high and low stress day. A single averaged composite score from all six days was calculated from each of the four stress measures. Stress was also determined by taking a daily average from each of the four stress measures, daily SUDS, Daily Stress Inventory-Event score, Daily Stress Inventory-Impact score, and Daily Stress Inventory-Ratio score, yielding six days of data for each measure. Finally, the Daily Stress Inventory also yielded a "diabetic daily hassles score" which was a measure of the intensity of diabetic hassles encountered each day.

Blood glucose was represented as a single averaged composite blood glucose score for each group. Blood glucose was also calculated as averages of all four daily BG measures, yielding six days of data. An overall BG range was also determined, which involved subtracting the lowest BG measure from the highest BG measure each day, and then figuring a single averaged score from those difference scores. One glycosylated hemoglobin score was also obtained for each participant for the entire study.

A single averaged score for each day of the six day assessment was recorded for the pedometer, yielding six

pedometer scores, in number of steps, for each participant. The Physical Activity Scale for the Elderly also yielded scores from three separate categories (1) "minutes spent doing household activities", (2) "minutes spent doing physical activities", and (3) "minutes spent doing leisure activities." Minutes spent at a job working were also obtained from participants.

## RESULTS

### Preliminary Analyses

Demographic and matching variables were compared using two-tailed t-tests for paired samples and Mann-Whitney U - Wilcoxon Rank Sum W tests to identify any differences between groups. Diet data were analyzed using Mann-Whitney U - Wilcoxon Rank Sum W Test to determine differences between the two groups which may have affected BG readings.

### Primary Analyses

Stress and BG were analyzed to test the three main hypotheses:

1. Blood glucose would be higher on high stress compared to low stress days
2. Exercise participants would have lower stress ratings compared to control participants.
3. Exercise participants would have lower BG readings compared to control participants.

Finally, activity was analyzed to determine possible correlation's with BG or stress and to test differences in activity between the two groups. Pearson correlation coefficients and one-tailed t-tests for paired samples were used for the above-mentioned analyses.

### Demographic Variables

Demographic data were analyzed using two-tailed t-tests for paired samples and Mann-Whitney U - Wilcoxon Rank Sum W tests for sixteen participants, with an average duration of time since diabetic diagnosis of 5.5 years ( $M = 3.75$ ,  $SD = 3.92$  control;  $M = 7.25$ ,  $SD = 4.37$  exercise). The frequency, means, and standard deviations of the demographic data are shown by Table 1.

Table 1  
Demographic Variables

	Exercise	Control
Marital Status	7 married	6 married
	0 divorced	1 divorced
	1 widowed	1 widowed
Occupation	3 retired	0 retired
	4 homemaker	2 homemaker
	0 part-time	2 part-time
	1 full-time	4 full-time
Oral Medication	5 yes	4 yes
	3 no	4 no
Body Mass Index Category	4 obese	6 obese
	3 overweight	1 overweight
	1 acceptable	1 acceptable

Table 1-Continued

	Exercise	Control
Years Education	15 (6.2)	14.7 (3.4)
Other Medical Diagnosis	1.8 (2.3)	1.0 (.54)

No significant differences between groups were found for marital status, oral medication use, body mass index category, years of education, number of other medical diagnoses, and number of other medications. A significant difference between groups was found with regard to occupation, with more of the participants in the control group working part or full time and more participants in the exercise condition retired or working at home (control mean rank = 11.25; exercise mean rank = 5.75;  $p < .05$ ). A significant difference was also found between groups for number of years married, with exercise participants being married for more years (control mean = 14.69, exercise mean = 35.25;  $p < .05$ ). Finally, two-tailed t-tests for paired samples found no differences between the two groups on number of trials required for diet or BG training, which was calculated during the initial training session.

Participants in the exercise and control groups were matched for gender, age, body mass index, and duration of diabetes. The frequency, means, and standard deviations of



the variables are represented in Table 2. No significant differences between the two groups were found on the matching variables using two-tailed t-tests for paired samples and Mann-Whitney U - Wilcoxon Rank Sum W tests.

Table 2  
Matching Variables

	Exercise	Control
Gender	6 female 2 male	5 female 3 male
Age	63.1 (8.8)	54.1 (10.6)
BMI	29.5 (7.2)	33.0 (6.1)
Years Diagnosed	7.3 (4.4)	3.8 (3.9)

#### Nutrient Intake

Mann-Whitney U - Wilcoxon Rank Sum W tests were used for comparison to examine differences between the two groups with respect to diet. The exercise group was found to have significantly higher protein on one of the two days ( $p = .045$ ).

### Blood Glucose and Stress

None of the t-tests for paired samples was significant when testing the hypothesis that participants would have higher BG readings on high stress versus low stress days. These data can be seen in Table 3.

Table 3

Average BG Ratings Compared on High and Low Stress Days

	Mean Average BG	One-tailed p
Daily SUDS		.08
High	137.84	
Low	129.88	
DSI Event		.29
High	128.44	
Low	124.99	
DSI Impact		.28
High	129.01	
Low	125.31	
DSI Ratio		.49
High	125.58	
Low	125.48	

All four of the stress measures showed that BG results were in the expected direction, but statistical

significance was not attained. Figure 1 shows a visual representation of BG on high versus low stress days.

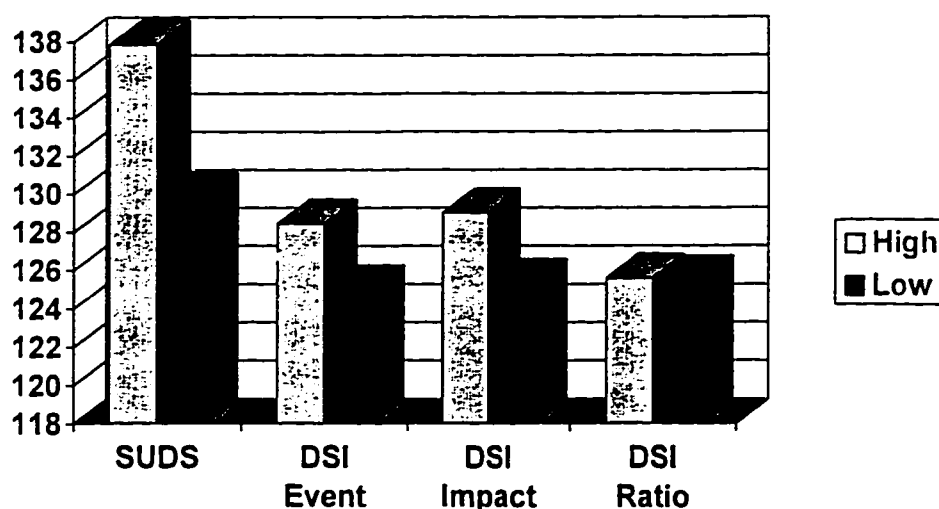


Figure 1. Average Blood Glucose on High Versus Low Stress Days.

Pearson correlation coefficients were computed, and daily average BG readings were found to be correlated with only three daily SUDS ratings as can be seen in Table 4. Daily average BG was not correlated with any other stress ratings.

#### Comparisons of Stress by Group

T-tests for paired samples were used to test the hypothesis that the control group would have higher stress ratings compared to the exercise group. These data are shown in Table 5. The control group had significantly greater Daily Stress Inventory-Ratio scores ( $p < .05$ ) when

Table 4  
Correlations of Average Daily BG and  
Average Daily SUDS Ratings

Blood Glucose	Stress (SUDS)					
	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Day 2	<b>.55</b>	.77	.09	.80	.62	.48
Day 3	.91	<b>.49</b>	.03*	.51	.40	.99
Day 4	.67	.28	<b>.08</b>	.96	.57	.17
Day 5	.86	.84	.18	<b>.91</b>	.96	.48
Day 6	.39	.19	.01**	.76	<b>.46</b>	.87
Day 7	.77	.63	.04*	.29	.71	<b>.92</b>

\*  $p < .05$ ; \*\*  $p < .01$

Table 5  
Composite Stress Ratings for Four Stress Measures

	Mean Exercise	Mean Control	One-tailed p
DSI Ratio	2.07	2.56	.02*
DSI Event	5.32	5.31	.994
DSI Impact	15.15	14.57	.21
Daily SUDS	3.14	2.9	.04*

\*  $p < .05$ ; \*\*  $p < .01$

all six days were combined to create a single stress score for each group from each of the four stress measures.

Further subdivision of the stress data was performed by comparing the groups on the six days for each of the individual four stress measures as demonstrated by Table 6. None of the one-tailed t-tests for paired samples was significant, but the differences between groups was in the expected direction on four of the six days on Daily Stress Inventory-Event scores and daily SUDS, and on five of the six days on Daily Stress Inventory-Ratio scores.

Table 6  
Average Stress Ratings for Four Stress Measures

	Mean Exercise	Mean Control	One-tailed p
DSI Event			
Day 2	5.88	6.75	.32
Day 3	7.13	5.00	.17
Day 4	4.13	5.00	.36
Day 5	5.25	6.00	.40
Day 6	5.88	5.38	.42
Day 7	3.63	3.75	.48
DSI Impact			
Day 2	15.38	17.00	.39
Day 3	15.63	13.88	.36
Day 4	10.63	14.88	.24
Day 5	14.63	18.13	.34
Day 6	20.75	15.38	.33
Day 7	13.88	8.13	.28
DSI Ratio			
Day 2	2.28	2.44	.39
Day 3	1.80	2.92	.12
Day 4	2.40	3.07	.28
Day 5	1.87	3.08	.13

Table 6-Continued

	Mean Exercise	Mean Control	One-tailed p
DSI Ratio			
Day 6	2.23	2.39	.44
Day 7	1.84	1.44	.32
Daily SUDS			
Day 2	3.09	3.10	.49
Day 3	2.63	3.05	.29
Day 4	2.79	2.81	.49
Day 5	2.91	3.20	.36
Day 6	3.64	2.91	.27
Day 7	3.76	2.33	.11

None of the one-tailed t-tests for paired samples was statistically significant when comparing groups on diabetic "daily hassle" scores (Table 7). The exercise group had a

Table 7  
Diabetic Daily Hassle Averages

	Mean Exercise	Mean Control	One-tailed p
DDHS			
Day 2	4.00	3.88	.48
Day 3	3.63	3.00	.35
Day 4	3.38	2.75	.36
Day 5	3.00	3.75	.32
Day 6	4.63	3.63	.32
Day 7	3.00	2.00	.16

higher number of daily hassles on five of the six days.

### Comparisons of Blood Glucose by Group

Statistical significance was found when testing the hypothesis that the control participants would have higher BG readings compared to exercise participants. The control group had significantly greater BG readings (141.41 = control; 129.58 = exercise;  $p < .001$ ) when all six days were combined to create a single BG score for each group. The control group also had greater range of BG compared to the exercise group (58.65 = control; 55.25 = exercise;  $p < .05$ ).

Further inspection of the BG data was conducted by examining the six days of data individually. The control group had a significantly higher BG reading on only one day. However, control participants had higher average BG readings on all 6 days as shown by Table 8. Figure 2 allows for a visual representation of the data.

One-tailed t-tests for paired samples showed that glycosylated hemoglobin was neither significantly different between the exercise and control groups (8.15 = control; 6.84 = exercise), nor was it correlated with any of the stress or BG measures using Pearson correlations.

Table 8

## Average BG Ratings Comparing Exercise and Control Groups

	Mean Exercise	Mean Control	One-tailed p
BG Day 2	134.19	141.49	.33
BG Day 3	133.82	145.05	.29
BG Day 4	125.52	145.96	.02*
BG Day 5	122.46	135.30	.16
BG Day 6	130.47	139.21	.29
BG Day 7	131.00	141.43	.14

\*  $p < .05$ ; \*\*  $p < .01$

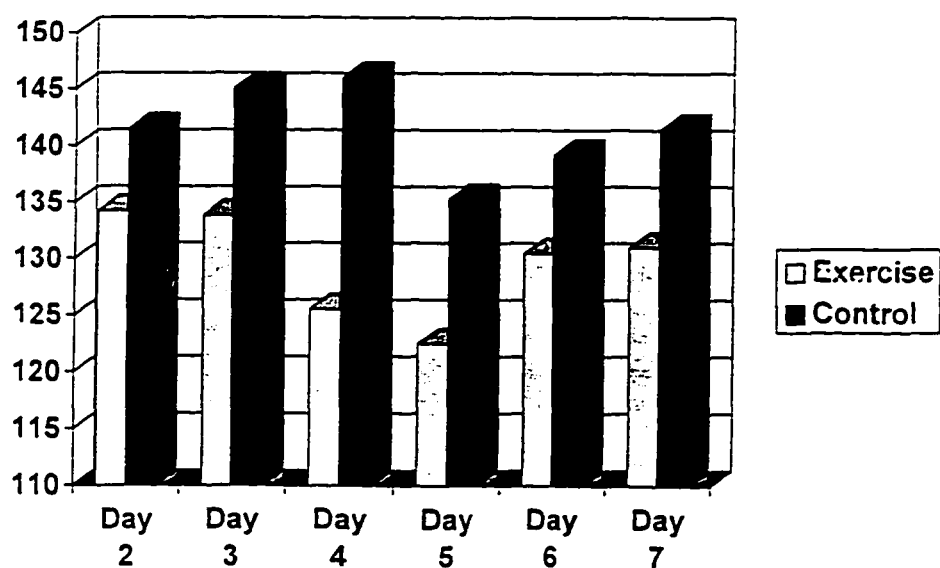


Figure 2. Average Blood Glucose Ratings for Exercise and Control Participants.



### Activity

Pearson correlation coefficients were calculated between activity and stress and BG readings. Blood glucose was not correlated with either "active minutes," "work minutes," or pedometer ratings. Stress was correlated with a few of the activity ratings (Table 9).

Table 9  
Pearson Correlation Coefficients  
Activity and Stress

Stress Measures				
	DSI-Event	DSI-Impact	DSI-Ratio	SUDS
<b>Activity</b>				
<u>Pedometer Reading</u>		p = .04		
<u>Active Minutes</u>		p = .04	p = .03	p = .04 p = .04 p = .05
<u>Work Minutes</u>	p = .001		p = .04	

One-tailed t-tests for paired samples were performed to examine differences between groups on the sub-categories of the Physical Activity Scale for the Elderly scale including "household activities," "leisure time activities," and "active minutes." These data can be found in Table 10.

Only one of the tests was statistically significant, but the exercise group had more minutes spent in activity based on greater mean scores on four of the six days for "household activities," greater mean scores on all six days for "leisure time activities," and greater mean scores on all six days for "active minutes" compared to the control group.

Table 10

Comparison of Means (in Minutes) for Household Activities, Leisure Activities, and Active Minutes From the PASE

	Mean Exercise	Mean Control	One-tailed p
<b>Household Activities</b>			
Day 2	210.00	193.75	.44
Day 3	223.13	320.63	.19
Day 4	178.13	167.50	.45
Day 5	181.25	200.00	.40
Day 6	440.63	207.50	.07
Day 7	298.75	153.13	.17
<b>Leisure-Time Activities</b>			
Day 2	212.50	155.00	.19
Day 3	286.88	121.25	.00**
Day 4	208.75	120.00	.10
Day 5	185.63	141.88	.19
Day 6	226.25	126.88	.08
Day 7	215.63	141.25	.12
<b>Active Minutes</b>			
Day 2	245.00	166.25	.09
Day 3	243.75	191.88	.30
Day 4	191.88	126.25	.12
Day 5	205.63	198.13	.46
Day 6	355.63	254.38	.20

Table 10-Continued

	Mean Exercise	Mean Control	One-tailed p
Active Minutes			
Day 7	236.88	163.13	.26

\*  $p < .05$ ; \*\*  $p < .01$

The control group had three days of significantly higher pedometer readings, and higher pedometer readings on all seven days. One-tailed t-tests for paired samples analyses were used to compare the two groups (Table 11). The control group had two days of significantly more minutes at work, and a greater number of minutes at work

Table 11

Average Pedometer Readings (Number of Steps) Comparing Exercise and Control Groups

	Mean Exercise	Mean Control	One-tailed p
Day 2	6546.00	8551.00	.20
Day 3	5040.50	7570.25	.03*
Day 4	5879.50	8369.50	.05*
Day 5	5949.63	9554.63	.07
Day 6	8081.75	10204.13	.16
Day 7	4506.25	8234.50	.04*

\*  $p < .05$ ; \*\*  $p < .01$

for all six days (Table 12). Number of minutes spent working at a job were compared via one-tailed t-tests for paired samples.

Table 12  
Average Number of Work Minutes Comparing  
Exercise and Control Groups

	Mean Exercise	Mean Control	One-tailed p
Work Minutes			
Day 2	82.50	161.25	.17
Day 3	52.50	168.75	.11
Day 4	37.50	266.25	.03*
Day 5	45.00	168.75	.09
Day 6	37.50	108.75	.20
Day 7	30.00	191.25	.04*

\*  $p < .05$ ; \*\*  $p < .01$

### Summary

In summary, this study hypothesized that BG would be higher on high stress compared to low stress days, and that stress and BG would be higher in control compared to exercise participants. The hypothesis that BG was higher in control compared to exercise participants was supported. The hypotheses that BG was higher on high stress compared

to low stress days, and that stress was higher in control compared to exercise participants were not supported. Other analyses found that demographic and matching variables were not significantly different between groups, with the exception of occupation and years married. A few significant differences were found for activity on individual days. The exercise group had more minutes spent in activities, while the control group had higher pedometer readings. Finally, the control group was more often working and spent more minutes at a formal job.

## DISCUSSION

This study supported the hypothesis that BG was higher in control compared to exercise participants. Analyses of individual days as well as composite BG readings demonstrated that control participants had higher BG as well as higher BG variability.

Epidemiological studies have found correlations between degree of hyperglycemia and frequency, severity, and rate of progression of complications (Skyler, 1987), while clinical studies have been more equivocal. The Diabetes Control and Complications Study (DCCT; Crofford, 1995) was a long-term follow-up study of a large number of participants which found significant reductions in diabetic risk factors following intensive treatment. However, normalization of glucose values was not achieved in the intensively treated cohort, and mean glucose values were approximately 40% above normal limits. Therefore, tight control of glucose is an important goal, potentially as considerable as normalization. This study did find that exercise participants had a lower range of BG, therefore maintaining tighter control of their BG compared to control participants.

The results of this study did not demonstrate that BG was higher on high stress compared to low stress days.

However, higher BG ratings existed on high stress compared to low stress days on all four stress measures. Although statistical significance was not found, the results do support a trend in the expected direction for BG to rise with higher reported stress.

Surprisingly, the control group did not have significantly higher stress scores compared to the exercise group when individual days were analyzed. There was a trend for control participants to have more days of higher reported stress on three of the four measures, but these differences were quite small. Therefore, although a trend in the expected direction was identified, the results did not find a positive stress-BG relationship, nor that exercise functioned as a "buffer" against stress. Because of the small sample size and low range of BG in participants, there may not have been enough power to demonstrate statistically significant differences if they had existed.

Statistical significance was not obtained when comparing the two groups on diabetic daily hassles, but those in the exercise group reported a higher number of daily hassles related to their diabetes on five of the six monitoring days. It is feasible that maintaining a regular schedule of exercise might contribute to higher stress, as the literature has shown poor compliance to the diabetic

regimen secondary to the complex behavioral changes that are necessary (Bennett-Johnson, 1992).

Interestingly, this study also found that control participants had higher pedometer readings on all six days, which may suggest a possible reason for minimal differences between stress ratings. Control participants were not sedentary as anticipated and were also working, in contrast to exercise participants who were primarily retired.

Conversely, in spite of a lack of significant differences, there was a trend for exercise participants to be engaged in more leisure time activities and to be active a greater portion of the day for all six monitoring days. They also were involved in more household activities on four of the six days. The exercise participants appeared to have incorporated more dynamic lifestyle activities into their daily regimens, consistent with that recommended by diabetes researchers (National Institutes of Health, 1986).

This study differs from most other studies by the utilization of an exercise and a matched control non-exercising group (Hornsby, Boggess, Lyons, Barnwell, Lazarchick, & Colwell, 1990; Reitman, Vasquez, Klimes, & Nagulesparan, 1984; Rogers, 1989; Rogers, Yamamoto, King, Hagberg, Ehsani, & Holloszy, 1988; Trovati, Carta, Cavalot, Vitali, Banaudi, Lucchina, Fiocchi, Emanuelli, & Lenti, 1984; Wallberg-Henriksson, Gunnarsson, Defronzo, Ostman, &



Wahren, 1982; Yeater, Ullrich, Maxwell, & Goetsch, 1990). Participants in this study were matched and did not differ significantly, for age, gender, duration of diabetes, and body mass index, variables which might affect BG. Also, participants did not significantly differ on any demographic variables, with the exception of occupation and years married. Therefore, the matched control design in combination with control and monitoring of diet and exercise adds to the power of this study, and has implications for future research.

There is a paucity of studies using control groups, and it is possible that large differences in this study were not discovered because differences between groups were examined rather than having participants serve as their own controls. A few studies have found improvements in BG in exercise participants compared to controls (Schneider, Amorosa, Khachadurian, & Ruderman, 1984; Schneider, Khachadurian, Amorosa, Clemow, & Ruderman, 1992), while others have found acute glucose-lowering effects of exercise with no lasting change in fasting plasma glucose and glycosylated hemoglobin (Zinman, Zuniga-Guajardo, & Kelly, 1984).

### Limitations

The lack of significant stress differences between groups may be the result of deficits in how stress was defined. Stress is related to an imbalance in an individual's optimal equilibrium and may be derived from numerous sources including environmental, social, physiological, and self-generated factors (Davis, Eshelman, & McKay, 1995). Because of the numerous determinants which may constitute a stressful stimulus as well as the variability inherent in how individuals react and cope with stress, a universal definition of stress is difficult to generate. Hence, the characteristics of the stressful stimulus as well as the person's interpretation of the event are important to delineate when describing stress for any specific individual.

Three ways to look at stress are (1) environmental events that precipitate a stress response, (2) the individual's subjective interpretation and experience of that environmental event, and (3) the physiological responses of the individual (Cohen, Kessler, and Gordon, 1995). Measurement of stress is most effective if it incorporates and integrates all three components. From this, it would appear that a useful way to study stress and how it affects BG is a multifaceted approach.

Prospectively, this could consist of daily recording of frequency and intensity of stressors, subjective reactions of the person, daily urine collection to measure cortisol and other levels of stress hormones in the urine, choosing a self-report measure that would identify the impact of individual stressors that last for prolonged periods of time, factoring out possible mediators of stress, daily self-monitoring of adherence to the diabetic regimen, and daily BG. Rather than using subjective measurements only, it would have been useful to incorporate physiological measurements such as urine cortisol, heart rate, and blood pressure and to include social support, coping, and locus of control measures.

Additionally, participants showed low variability in their stress ratings even though an attempt was made for each rating to be made independently of previous ratings. Each stress rating was made on a separate sheet of paper, but participants tended to stay within a certain stress range. Because of this restriction of range, variability was low, and large differences were not found. A measure that allows for greater variability would have been useful. A scale that measures stress on a continuum greater than 0-10, and a self-report measure that identifies the impact of individual stressors that last for prolonged periods of time (e.g. Life Events Scale) would fulfill this criterion.

The small number of participants in this study further limits its generalizability and ability to detect large differences between groups. Although a few studies have found significant differences with as few as eight participants, the inclusion of more NIDDM diabetics would have been advantageous.

Another possible limitation of this study was that BG readings were in fairly normative ranges. The highest mean BG for the control group was 145.96, and for the exercise group was 134.19. These BG readings were not too divergent from well controlled diabetes BG values (fasting 60-130 mg/dl), and the inclusion of participants with more pathological BG values, such as in the upper 200-300's, would have allowed for greater detection of differences between groups.

A problem with the methodology of this study was that participants did not rotate their diet as precisely as instructed. An attempt was made to amend this limitation by creating adequacy variables to compare groups on nutritional status. The groups did not differ significantly with respect to nutritional status. However, because diet was not explicitly controlled for each participant, it is feasible that diet may have affected some of the BG readings.

Finally, a possible explanation for the lack of statistically significant results may be that participants in the exercise group were chosen retrospectively from an exercise program rather than entering prospectively into an exercise intervention. A prospective aerobic exercise intervention would have added to the power of this study.

Based on the aforementioned limitations, a number of alterations to this study design would be beneficial for future, controlled studies. Recommendations include physiological measurements for stress, further refinement of stress definitions, larger samples, using participants with more pathological BG readings, structuring diet and exercise throughout the study, and prospective exercise treatment programs.

#### Future Directions

In addition to the above-mentioned enhancements to the experimental design, it would be useful to conduct more controlled matching of groups. Groups in this study differed on years married and occupation, which have not been described in the literature as important for BG control. However, these variables may have affected the results because the control group was working more hours and had more pedometer steps, presumably because they were working, and were not sedentary as predicted. It would therefore be

useful to screen and match participants based on the variables of age, gender, body mass index, duration of diabetes, as well as occupation.

Another useful matching variable to include would be measures of activity prior to the study. Potential participants could monitor their number of steps and self-record activity prior to initiation of a formal exercise program. Persons could be put into a sample based on similar activity levels, and then randomly assigned to exercise or no-exercise groups. This would control for any pre-exercise differences between groups on activity.

Finally, identifying those individuals who respond to stress versus those who don't in a laboratory paradigm would be useful to examine differences between those two groups (Goetsch, 1989). Separation and study of those two groups using an exercise paradigm would possibly generate useful information regarding the stress, exercise, and BG relationship.

In summary, the results of this study did support the contention that BG was lower in exercise compared to control participants. Differences between groups on stress measures were equivocal. Further methodological enhancements as delineated would be useful for future studies. This study added to the literature base, encouraged the use

of control groups, and provided a useful base for the formulation of additional research.

## Appendix A

### Protocol Clearance From the Human Subjects Institutional Review Board





---

WESTERN MICHIGAN UNIVERSITY

---

Date: Feb 10, 1995

To: Clemensen, Lisa

From: Richard Wright, Interim Chair

Re: HSIRB Project Number 94-11-30

*Richard A. Wright*

This letter will serve as confirmation that your research project entitled "Effects of aerobic exercise on blood glucose and reactivity to psychosocial stressors in Non-insulin dependent diabetics" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you must seek specific approval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date. In addition if there are any unanticipated adverse or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: Feb 10, 1996

xc: Spates, PSY



DATE: February 14, 1995

NOTICE OF APPROVAL FOR PROTOCOL #12222 - ADDENDUM #5  
Adding Western Michigan U  
Telephone Number to Consent

This research will be monitored for re-approval annually.  
This protocol was first approved on 10/15/91

TO: Irma Ullrich/R. Yeater/V. Goetsch/R. Hoeldtke/J. Findley/  
J. Triplett/L. Hock/M. Davidson/C. Tyson/L. Clemensen

PROJECT TITLE: Physiological Reactivity to Mental Stress

SPONSORING AGENCY\*: N/A

The Institutional Review Board for the Protection of Human Research Subjects (IRB) has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes in your Protocol/consent form be necessary, **prior approval must be obtained from the IRB.**

According to the Code of Federal Regulations, Section 312.32, investigators are required to notify the FDA and the Study Sponsor of any adverse experience associated with the use of an investigational drug that is serious and unexpected. A serious adverse experience is considered any event that is fatal or life-threatening, is permanently disabling, requires inpatient hospitalization, or is a congenital anomaly, cancer or overdose. An unexpected adverse experience is an event that is not identified in nature, severity or frequency in the current investigator brochure. Any experience reportable to FDA and the sponsor must also be reported immediately to the IRB.

A Consent Form   X   is        is not required of each subject.

An Assent Form        is   X   is not required of each subject.

A recruitment ad has   X   has not        been approved.



\*Only copies of the Consent and/or Assent Form with the IRB's approval stamp may be used with human subject research. It is the responsibility of the investigator to submit a revised Consent Form for the IRB's approval should funding be obtained. This stamped Consent Form must then be used for subjects enrolled. A copy of each subject's signed Consent/Assent Form must be retained by the investigator and accessible to federal regulatory authorities for at least three years after the study is completed.

Marian J. Turner /LL

Marian J. Turner  
IRB/ACUC Administrator

MJT/maa

bcc: L. Clemens



DATE: March 13, 1995

NOTICE OF APPROVAL FOR PROTOCOL H.S. #12222 - ADDENDUM #6  
Changing Upper Age of Subjects from 70 yrs to 80 yrs

This research will be monitored for re-approval annually.  
This protocol was first approved on 10/15/91

TO: Irma Ullrich/R. Yeater/V. Goetsch/R. Hoeldtke/J. Findley/  
J. Triplett/L. Hock/M. Davidson/C. Tyson/L. Clemensen

PROJECT TITLE: Physiological Reactivity to Mental Stress

SPONSORING AGENCY\*: N/A

The Institutional Review Board for the Protection of Human Research Subjects (IRB) has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes in your protocol/consent form be necessary, prior approval must be obtained from the IRB.

According to the Code of Federal Regulations, Section 312.32, investigators are required to notify the FDA and the Study Sponsor of any adverse experience associated with the use of an investigational drug that is serious and unexpected. A serious adverse experience is considered any event that is fatal or life-threatening, is permanently disabling, requires inpatient hospitalization, or is a congenital anomaly, cancer or overdose. An unexpected adverse experience is an event that is not identified in nature, severity or frequency in the current investigator brochure. Any experience reportable to FDA and the sponsor must also be reported immediately to the IRB.

A Consent Form   X   is        is not required of each subject.

An Assent Form        is   X   is not required of each subject.

A recruitment ad has   X   has not        been approved.



Page 2  
H.S. #12222  
ADDENDUM #6  
Irma Ullrich  
3/13/95

\*Only copies of the Consent and/or Assent Form with the IRB's approval stamp may be used with human subject research. It is the responsibility of the investigator to submit a revised Consent Form for the IRB's approval should funding be obtained. This stamped Consent Form must then be used for subjects enrolled. A copy of each subject's signed Consent/Assent Form must be retained by the investigator and accessible to federal regulatory authorities for at least three years after the study is completed.

Marian J. Turner/MAA

Marian J. Turner  
IRB/ACUC Administrator

MJT/maa

**Appendix B**  
**Demographic Questionnaire**

SUBJECT #: \_\_\_\_\_

67

PLEASE CIRCLE OR FILL IN THE APPROPRIATE RESPONSE. THE EXAMINER  
WILL BE AVAILABLE TO ANSWER ANY QUESTIONS YOU MAY HAVE.

DATE: \_\_\_\_\_ Age: \_\_\_\_\_

Height: \_\_\_\_\_ Weight: \_\_\_\_\_

Gender: Male Female

Education Level: 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

Occupation: \_\_\_\_\_

Marital Status: Married Single Divorced Widowed Other

Years Married (if married) : \_\_\_\_\_

Diabetic Diagnosis: \_\_\_\_\_

Age When Received Diagnosis: \_\_\_\_\_

Medications (Please List):

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Other Medical or Psychiatric Diagnoses:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

How often do you monitor your Blood Glucose? \_\_\_\_\_

Aerobic Conditioning Program:

Land (Walking/Bicycle/Treadmill) Water None

Length of Aerobic Conditioning Program:

If you are currently involved in an aerobic conditioning program,  
how long have you been attending that program?

\_\_\_\_\_ month(s)

Have you been diagnosed with complications of NIDDM,  
including:

Retinopathy \_\_\_\_\_

Stroke \_\_\_\_\_

Central Neuropathy \_\_\_\_\_

Heart Disease \_\_\_\_\_

Autonomic Neuropathy \_\_\_\_\_

Other: \_\_\_\_\_

Appendix C  
Diet Monitoring Log



DIET LOG FOR WEDNESDAY, FRIDAY, AND SUNDAY

69

Date \_\_\_\_\_ Subject# \_\_\_\_\_

Day of Monitoring: FRIDAY

Please write down everything that you eat or drink today from the time you get up until you go to bed. Include drinks of all kinds and everything else you put into your mouth and swallow. Also, specify the amount, how it is prepared, and anything that is added such as butter, margarine, fat oil, salad dressing, sugar, syrup, etc.

Time and Meal

Food Eaten

DIET INSTRUCTIONS FOR DAYS 4 - 7  
(Monday, Wednesday, Friday, and Sunday)

70

Please complete the diet logs for the first 3 days (Wednesday, Friday, and Sunday) of the study. For the remaining 4 days of the study you will be eating the same foods you ate during the second and third days (Friday and Sunday) of the study by rotating your diet based on the following schedule:

- Repeat foods eaten on Friday and Sunday on Monday and Wednesday then again on Friday and Sunday.

For example:

<u>Wed.</u>	<u>Fri.</u>	<u>Sun.</u>	<u>Mon .</u>	<u>Wed .</u>	<u>Fri.</u>	<u>Sun.</u>
lg. apple	banana 1 cup rice with 1 Tbs.. butter	5 oz. steak	banana 1 cup rice with 1 Tbs.. butter	5 oz. steak	banana 1 cup rice with 1 Tbs.. butter	5 oz. steak

In the space below, indicate any additions or deletions from your assigned diet. Be sure to include the time, amount, and how it was prepared.

Monday  
(same as  
Friday)

Wednesday  
(same as  
Sunday)

Friday  
(same as  
Friday)

Sunday  
(same as  
Sunday)

**Appendix D**  
**Blood Glucose and SUDS Monitoring Form**

DATE \_\_\_\_\_

SUBJECT # \_\_\_\_\_

72

**BEDTIME**

On a scale of 1 to 10 rate your stress during the last 4 hours.

1	2	3	4	5	6	7	8	9	10
not at				moderately				extremely	
stressed				stressed				stressed	

Blood glucose \_\_\_\_\_

**Appendix E**  
**Physical Activity Scale for the Elderly**

8# \_\_\_\_\_

**INSTRUCTIONS:**

Please complete this questionnaire by filling in the blank for activities in which you participated today. If you did not participate in the activity named, do not fill in the blank. If you did participate in the activity, indicate number of minutes of your participation. Here is an example:

Saw the sun. \_\_\_\_\_

Please answer all items as accurately as possible. All information is strictly confidential. Please note that there is a blank for each day of the week following each activity.

**LEISURE TIME ACTIVITY**      Date: \_\_\_\_\_

1. Sitting activities such as reading, watching TV or doing handicrafts? \_\_\_\_\_

2. Took a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, etc.? \_\_\_\_\_

3. Light sport or recreational activities such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities? \_\_\_\_\_

4. Moderate sport and recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities? \_\_\_\_\_

5. Strenuous sport and recreational activities such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities? \_\_\_\_\_

6. Exercises specifically meant to increase muscle strength and endurance, such as lifting weights or pushups, etc.? \_\_\_\_\_

**HOUSEHOLD ACTIVITY**

7. Light housework, such as dusting or washing dishes. \_\_\_\_\_

8. Heavy housework or chores, such as vacuuming, scrubbing floors, washing windows, or carrying wood? \_\_\_\_\_

9. Home repairs like painting, wallpapering, electrical work, etc. \_\_\_\_\_

10. Lawn work or yard care, including snow or leaf removal, wood chopping, etc. \_\_\_\_\_

11. Outdoor gardening. \_\_\_\_\_

12. Caring for an other person, such as children, dependent spouse, or another adult. \_\_\_\_\_

**PEDOMETER READINGS** \_\_\_\_\_

**COMPLETE THE FOLLOWING SECTION ONLY IF YOU WORK FOR PAY OR AS A VOLUNTEER**

13. How many hours/minutes did you work for pay and/or as a volunteer?  
\_\_\_\_\_

14. Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work? (Circle the appropriate number)

- [1] Mainly sitting with slight arm movements. [Examples: office worker, watchmaker, seated assembly line worker, bus driver, etc.]
- [2] Sitting or standing with some walking. [Examples: cashier, general office worker, light tool and machinery worker.]
- [3] Walking, with some handling of materials generally weighing less than 50 pounds. [Examples: mailman, waiter/waitress, construction worker, heavy tool and machinery worker.]
- [4] Walking and heavy manual work often requiring handling of materials weighing over 50 pounds. [Examples: lumberjack, stone mason, farm or general laborer.]

**Appendix F**  
**Informed Consent**



CONSENT FORM

Effects of Aerobic Exercise on Blood Glucose and Reactivity  
to Psychosocial Stressors in Non-Insulin Dependent Diabetics.

Richard Spates, Ph.D., Lisa Clemensen, M.A., Michele  
Burnette, Ph.D., Virginia Goetsch, Ph.D.

Introduction. I, \_\_\_\_\_ have been invited to participate in this research study which has been explained to me by the experimenter. I understand that data from this study will be used to fulfill the requirements for a doctoral dissertation in Clinical Psychology at Western Michigan University as well as be used for a larger study being conducted at West Virginia University.

Purpose of the Study. The purpose of this study is to examine the effects of exercise on psychological stress and blood glucose functioning in persons with Type II diabetes. I understand that if I participate in this study I will meet with the experimenter for a training session and then conduct a seven day self-monitoring assessment period of glucose level, exercise, stress, and diet.

Description of Procedures. Approximately 16 subjects will be entered in this study. I am aware that height, weight, and a blood sample will be collected from me. I understand the experimenter will show me how to use a digital glucometer (a device that measures blood glucose), how to lance my finger for a drop of blood, and how to record the reading on a monitoring form. I will also be given a pedometer (a device that measures the number of steps taken and therefore distance travelled) and will learn how to wear it and record my daily activity. I will be given forms to record my blood glucose, diet, exercise, medication use and daily stress. I will be asked to record these readings for seven (7) days. The experimenter may phone me periodically to insure that I am not having difficulty with any of the recording procedures.

Following the seven (7) day monitoring period, I understand that I will be asked to return my monitoring forms, glucometer, and pedometer to the experimenter. After the assessment procedure, I will be debriefed and paid \$25.00 for my participation.

Benefits. There are no direct benefits to me other than a monetary compensation of \$25.00 to be paid at the completion of the assessment period. While there are no direct benefits to me for my participation in this study, I understand that

my participation may help further knowledge concerning factors that may affect the course of Type II diabetes.

78

Risks. Although risks associated with my participation in this study are minimal, I understand that some risks may be unforeseeable. If an accidental injury occurs no compensation or treatment will be made available to the subject except as otherwise stated in this consent form.

Contact Persons. I understand that I may contact Lisa Clemensen, M.A. or Virginia Goetsch, Ph.D. at (304) 293-2411 if I have any questions. I understand that if I have any questions about my rights as a research participant, I can contact the Institutional Review Board for the Protection of Human Subjects at West Virginia University at (304) 293-7073. I may also contact the Chair of the Human Subjects Institutional Review Board (616) 387-8293 or the Vice President for Research (616) 387-8298 at Western Michigan University if questions or problems arise during the course of the study.

Confidentiality. I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. However, I understand that the investigator might be required to give information to a third party if I represent a clear and imminent danger to myself or another person. I understand also that my research records, just like hospital records, may be subpoenaed by court order or may be inspected by federal regulatory authorities. In any publications that result from this research, neither my name nor any information from which I might be identified will be published without my consent.

Voluntary Participation. In signing this consent form, I state that I have read and understood the description of the monitoring procedures and questionnaires. Any questions I had have been answered to my satisfaction. To the best of my knowledge, I am not suffering from any impairment or disease that might interfere with my completion of this project.

I enter into this research willingly as a volunteer and may withdraw at any time without fear of retribution. Refusal to participate involves no penalty or loss of benefit to which I am entitled.

---

Participant's Signature

---

Date

---

Signature of Investigator  
or Investigator's Representative

---

Date



WEST VIRGINIA UNIVERSITY  
SCHOOL OF MEDICINE

James M. Stevenson, MD  
Professor and Chairman

For --

79

FEB 14 1995

CONSENT FORM

x *Marian J. Turner / L44*

Title of Study: The effects of stress on non-insulin-dependent diabetes mellitus.

Introduction. I, \_\_\_\_\_, have been invited to participate in this research study which has been explained to me by the investigator. Some data from this study may be used to fulfill the requirements for a doctoral dissertation in Clinical Psychology.

Purpose of the Study. The purpose of this study is to examine the effects of daily stress on blood glucose in persons with Type II diabetes. The goal of this study is to further knowledge about the effects of stress on individuals with Type II diabetes.

Description of Procedures. I understand that I will be asked to complete a number of questionnaires, which will take approximately forty-five (45) minutes. I understand that I may see any questionnaires before I sign this form.

I understand the investigator will show me how to use a digital glucose meter, how to lance my finger for a drop of blood, and how to record the reading on a monitoring form. I will be given forms to record my blood glucose, diet, exercise, medication use, and daily stress. In addition, I will be asked to wear a pedometer to record number of miles walked each day. I will be asked to record these readings for seven (7) consecutive days and during these seven (7) days, I will be asked to hold my diet and exercise constant. I also understand that I will be asked to collect a urine sample in the containers provided to me for the same seven (7) day period. I understand I will be asked to freeze each urine sample at the end of the day and return the samples to the investigator at the end of the study. The investigator may phone me periodically to insure I am not having difficulty with any of the recording procedures.

Following the seven (7) day monitoring period, I understand that I will be asked to return my monitoring forms, glucose meter, and urine samples to the investigator. I also will be asked to complete several questionnaires at this time which will take approximately thirty (30) minutes. I will then be debriefed, paid \$20.00 for my participation, and be allowed to leave.

Benefits. There are no direct benefits to me other than monetary compensation of \$20.00 to be paid at the completion of the study. While there are no direct benefits to me for my participation in this study, I understand that my participation will help further knowledge concerning factors that may affect the course of Type II diabetes.

Risks. Although risks associated with my participation in this study are minimal, I understand that some risks may be unforeseeable. Should injury occur as a result of this research, voluntary compensation is not provided. There are no costs or special fees for participating.

Contact Persons. I understand that I may contact the investigators, James Findley, M.S. (293-2001, ext. 839), LeighAnn Forsyth, M.A., (293-2001, ext. 842), Lisa Clemensen, M.A. (293-2411), or their supervisor, Virginia Goetsch, Ph.D. (293-2411) should the need arise. I understand that if I have any questions about my rights as a research participant, I can contact the West Virginia University Institutional Review Board for the Protection of Human Subjects at 293-7073, the Western Michigan University Human Subjects Institutional Review Board at (616) 387-8293, or the Vice President for Research at Western Michigan University at (616) 387-8298.

Department of Behavioral Medicine and Psychiatry

Chestnut Ridge Hospital 930 Chestnut Ridge Road, Morgantown, WV 26505-2854 Telephone 304-293-2411 FAX 304-293-5555  
Equal Opportunity/Affirmative Action Institution

Confidentiality. I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. I understand I will be identified by number only. However, I also understand that my research records, like hospital records, can be subpoenaed by court order or may be inspected by federal regulatory authorities. I understand that the investigator might be required to give information to a third party if I represent a clear and imminent danger to myself or another person.

Voluntary Participation. In signing this consent form, I state that I have read and understand the description of the monitoring procedures and questionnaires. Any questions have been answered to my satisfaction. To the best of my knowledge I am not suffering from any impairment or disease that might interfere with my completion of this project.

I enter into this research willingly as a volunteer and may withdraw at any time without fear of retribution. Refusal to participate involves no penalty or loss of benefit to which I am entitled. I will be given a signed copy of the consent form.

\_\_\_\_\_  
Participant's Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Investigator  
or Investigator's Representative

\_\_\_\_\_  
Date

**Appendix G**  
**Dietary Training Instructions**

## DIET TRAINING FORM

82

Have you received formal training from a nutritionist or dietician?

If yes, how long ago? \_\_\_\_\_ month(s) ago.

### STEPS FOR TRAINING:

Items necessary for training: 2 potatoes, 1 sliced (large slices) carrot, 1 cup of dry rice, 2 cups of water, 1 box of cereal (rice crispies), 1 medium sized plate, 1 medium sized bowl, 2 medium sized glasses, 1 measuring cup, and 1 food scale.

Subjects may estimate in cups or ounces, whichever is most familiar to them.

- 1) Give sample item (1 ounce of carrots) and demonstrate how to estimate weight of food. Do this by placing carrots on plate and stating "See, this is one ounce of carrots". Then place carrots on scale to demonstrate actual weight.
- 2) Place small amount of carrots on medium plate and have them estimate weight in ounces. Place food item on scale following estimation to demonstrate actual weight.
- 3) Place potato on medium plate and have them estimate weight in ounces. Place food item on scale following estimation to demonstrate actual weight.
- 4) Place approximately 1/2 cup of rice in a glass and then a bowl and have them estimate weight in ounces. Place food item on scale following estimation to demonstrate actual weight.
- 5) Place approximately 1/2 cup of cereal in a bowl and have them estimate weight in ounces. Place food item on scale following estimation to demonstrate actual weight.
- 6) Pour approximately 1 cup of water in a glass and have them estimate weight in ounces. Pour water into measuring cup to demonstrate actual weight.

Continue this procedure until subjects have correctly estimated the weight of four food items consecutively. Allow a -1/+1 ounce error range for each independent food item.

**Appendix H**  
**Blood Glucose Training Form**

## One-Touch Meter

### Meter Preparation

1. Clean the meter:
  - a) Remove the strip guide & rinse in warm water & soap; dry with a paper towel.
  - b) Wipe off the optical window with cleaning cloth.
  - c) Reassemble strip guide.
2. Run the calibration check on the electronics of the meter:
  - a) Insert check strip with the number 1 facing up.
  - b) Turn meter on.
  - c) When "apply sample" appears, remove check strip & insert with side 2 facing up.
3. Record the last memory entry (entry # & blood glucose value) in the subject's data folder.

### One-Touch Meter Instructions

1. Wash hand with warm water & soap.
2. Assemble supplies: meter, penlet with lancet, strips, alcohol swab, and log sheet.
3. Cock the penlet -- open alcohol swab.
4. Insert strip into meter with the blue Lifescan label side facing up, and close the door.
5. Turn on meter.
6. Verify that the code number on the screen matches the code # printed in red on the strip container.
7. Prep and poke finger.
8. Obtain a large, hanging drop of blood.
9. When meter says "apply sample", open door and place drop of blood onto white dot without letting your finger touch the strip.
10. Close the door -- the words "testing" should appear on the screen.
11. After 45 seconds, the meter will beep and your blood glucose will appear on the screen.
12. Record the time and blood glucose values on your log sheet.
13. Turn meter off.



Appendix I  
Pedometer Training Instruction Form

## PEDOMETER INSTRUCTIONS

1. Have S begin at some marker (e.g. doorknob, door frame, table edge, etc.) and walk ten (10) paces, beginning with the right foot. Have S plant left foot on last (10th) step.
  2. Place end of tape measure precisely next to the tip of S's left shoe. Ask S to step on and hold it in place. Pull tape measure back to original marker and record distance in feet and inches.
  3. Convert measurement into inches (multiply # feet X 12 + remaining inches). For example, if measurement = 25'9",  $25 \times 12 = 300 + 9$  (remaining inches) = 309.
  4. Divide measurement by number of paces.  $309/10 = 30.9$ .
  5. Convert measurement back to feet & inches.  $30.9/12 = 2.58$  (round to the even number if third decimal place - .005).
  6. Set right side switch to DIST. Set stride using button marked str/wt/st. Hold it down > 2 seconds and it will begin to move ahead in gradations of 4". Roughly speaking, if decimal is:
 

$< .17$  - round down     $> .17 < .50 = 4"$   
 $> .50 < .83 = 8"$      $> .83$  - round up
- So...stride in this example:  $2.56 = 2' 8"$
7. Set right side switch to STEPS. Have S attach pedometer to belt or waist band directly above knee.
  8. After pedometer is in place, have S hit reset button and walk 100 steps. If reading is < 95 move sensitivity switch (on outside, flat end) to a more sensitive (+) setting. If reading is > 105, move sensitivity switch to a less sensitive (-) setting. Have S repeat 100 steps, until you get 100 +/- 5 steps.
  9. Tell S to reset pedometer each morning after attaching it to their person. They should have it on if they are not in bed. Ss should minimize the number of times they remove/replace the pedometer during the day. Have them record the pedometer reading on the \_\_\_\_\_ before retiring each night.

Appendix J  
Daily Reminder Sheet

## Daily Reminder Sheet for Participants

88

- 1.) Clip-on your pedometer each morning.
- 2.) Rate your stress level before all 4 of your blood glucose testing times.
- 3.) Record your blood glucose levels at all 4 testing periods (before: breakfast, lunch, dinner, and bedtime).
- 4.) Record all food and liquid intake and rotate diet as indicated on diet monitoring forms.
- 5.) At bedtime each night: a.) Record your pedometer mileage, b.) Complete activity log (PASE), c.) Complete DSI.

## BIBLIOGRAPHY

- Aikens, J.E., Wallander, J.L., Bell, D.S.H, & Cole, J.A. (1992). Daily stress variability, learned resourcefulness, regimen adherence, and metabolic control in Type I diabetes mellitus: Evaluation of a path model. Journal of Consulting and Clinical Psychology, 60, 113-118.
- Ary, D.V., Toobert, D., Wilson, W., & Glasgow, R.E. (1986). Patient perspective on factors contributing to nonadherence to diabetes regimen. Diabetes Care, 9, 168-172.
- Bahrke, M.S., & Morgan, W.P. (1978). Anxiety reduction following exercise and meditation. Cognitive Therapy and Research, 2, 323-333.
- Bennett-Johnson, S. (1992). Methodological issues in diabetes research: Measuring adherence. Diabetes Care, 15, 1658-1667.
- Bliss, E.L., Migcon, C.J., Branch, C.H.H., & Samuels, L.T. (1956). Reaction of the adrenal cortex to emotional stress. Psychosomatic Medicine, 18, 56-76.
- Blood Glucose Monitors (1988). Health Devices, 17 (9), 253-271.
- Blumenthal, J., Emery, C., Walsh, M., Cox, D.R., Kuhn, C.M, Williams, R.B., & Williams, R.S. (1988). Exercise training in healthy type A middle-aged men: Effects on behavioral and cardiovascular responses. Psychosomatic Medicine, 50, 418-433.
- Bradley, C., Moses, J.L., Gansu, D.S., Knight, G., & Ward, J.D. (1985). The effects of relaxation on metabolic control in Type I diabetics: A matched controlled study. Diabetes, 34 (Suppl.), 17A.
- Brantley, P.J., & Jones, G.N. (1993). Daily stress and stress-related disorders. Annals of Behavioral Medicine, 15 (1) 17-25.
- Bray, G.A. (1978). Definition, measurement, and

- classification of the syndromes of obesity.  
International Journal of Obesity, 2 (2), 1-14.
- Cannon, W. (1941). Bodily changes in pain, hunger, fear, and rage. New York: Macmillan Press.
- Carter, W.R., Gonder-Frederick, L., Cox, D., Clarke, W., & Scott, D. (1985). Effects of stress on blood glucose in IDDM. Diabetes Care, 8, 411-412.
- Carter, W.R., Herrman, J., Stokes, K., & Cox, D.J. (1987). Promotion of diabetes onset by stress in the BB rat. Diabetologia, 30, 674-675.
- Chase, H.P., & Jackson, G.G. (1981). Stress and sugar control in children with insulin-dependent diabetes mellitus. Journal of Pediatrics, 98, 1011-1013.
- Clayton, R., Cox, R., Howley, E., Lawler, K., & Lawler, J. (1988). Aerobic power and cardiovascular response to stress. Journal of Applied Physiology, 65, 1416-1423.
- Cohen, S., Kessler, R.C., & Gordon, L.U. (1995). Measuring Stress. A guide for health and social scientists. New York, New York: Oxford University Press, Inc.
- Cox, D.J., Gonder-Frederick, L., Clarke, W., & Carter, W. (1988). Effects of acute experimental stressors on insulin-dependent diabetes mellitus. Diabetes, 37 (Suppl.), 51A.
- Cox, D.J., Taylor, A.G., Nowacek, G., Holley-Wilcox, P., Pohl, S.L., & Guthrow L. (1984). The relationship between psychological stress and insulin-dependent diabetic blood glucose control: Preliminary investigations. Health Psychology, 3, 63-75.
- Craighead, J.E. (1978). Current view on the etiology of insulin-dependent diabetes mellitus. New England Journal of Medicine, 299, 1439-1445.
- Crews, D., & Landers, D. (1987). A meta-analytic review of aerobic fitness and reactivity to psychosocial stressors. Medical Science in Sports and Exercise, 19, S114.
- Crofford, O.B. (1995). Diabetes control and complications. Annual Review of Medicine, 46, 267-279.

- Davis, M., Eshelman, E.R., & McKay, M. (1995). The relaxation and stress reduction workbook (4th edition). California: New Harbinger Publications, Inc.
- DCCT (1993). The New England Journal of Medicine, 329, 977-986.
- DeFronzo, R.A., Bonadonna, R.C., & Ferrannini, E. (1992). Pathogenesis of NIDDM: A balanced overview. Diabetes Care, 15, 318-368.
- DeFronzo, R.A., Ferrannini, E., & Koivisto, V. (1983). New concepts in the pathogenesis and treatment of non-insulin-dependent diabetes mellitus. American Journal of Medicine, 74, 52-81.
- Delamater, A.M., Kurtz, S.M., Bubb, J., White, N.H., & Santiago, J.V. (1987). Stress and coping in relation to metabolic control of adolescents with Type I diabetes. Developmental and Behavioral Pediatrics, 8, 136-140.
- Diabetes Mellitus and Exercise (1991). Position Statement of the American Diabetes Association. Diabetes Care, 14, 36.
- Edwards, C., & Yates, A. (1985). The effects of cognitive task demand on participants stress and blood glucose levels in diabetics and nondiabetics. Journal of Psychosomatic Research, 29, 59-69.
- Feinglos, M.N., Hastedt, P., & Surwit, R.S. (1987). Effects of relaxation therapy on patients with Type I diabetes mellitus. Diabetes Care, 10, 72-75.
- Felig, P., & Wahren, J. (1975). Fuel homeostasis in exercise. New England Journal of Medicine, 293, 1078-1084.
- Gerich, J.E., Lorenzi, M., Tsalikian, E., & Karam, J. (1976). Studies of the mechanism of epinephrine-induced hyperglycemia in men. Diabetes, 25, 65.
- Glasgow, R.E., McCaul, K.D., & Schafer, L.C. (1984). Barriers to regimen adherence among persons with insulin-dependent diabetes. Journal of Behavioral Medicine, 9, 65-77.

- Glasgow, R.E., McCaul, K.D., & Schafer, L.C. (1987). Self-care behaviors and glycemic control in type 1 diabetes. Journal of Chronic Diseases, 40, 399-412.
- Glasgow, R.E., Toobert, D.J., Riddle, M., Donnelly, J., Mitchell, D.J., & Calder, D. (1989). Diabetes-specific social learning variables and self-care behaviors among person with type II diabetes. Health Psychology, 8, 285-303.
- Goetsch, V.L. (1989). Stress and blood glucose in diabetes mellitus: A review and methodological commentary. Annals of Behavioral Medicine, 11, 102-107.
- Goetsch, V.L., Pbert, L.A., VanDorsten, B., & Yeater, R.A. (1988). The effects of aerobic exercise on blood glucose reactivity in type II diabetics. Paper presented at the meeting of the Society of Behavioral Medicine, Boston, MA.
- Goetsch, V.L., VanDorsten, B., Pbert, L., Ullrich, I., & Yeater, R. (1993). Acute effects of laboratory stress on blood glucose in non-insulin dependent diabetics. Psychosomatic Medicine, 55, 492-496.
- Goetsch, V.L., & Wiebe, D.J. (1994). Diabetes Mellitus: Considerations of the influence of stress. In A. Goreczny (Ed.), Handbook of Health and Rehabilitation Psychology. New York: Plenum Press.
- Goetsch, V.L., Wiebe, D.J., Veltum, L., & VanDorsten, B. (1990). Stress and blood glucose in Type II diabetes mellitus. Behaviour Research and Therapy, 28, 531-537.
- Halford, W.K., Cuddihy, S., & Mortimer, R.H. (1990). Psychological stress and blood glucose regulation in Type I diabetic patients. Health Psychology, 9, 516-528.
- Hanson, S.L., & Pichert, J.W. (1986). Perceived stress and diabetes control in adolescents. Health Psychology, 5, 439-452.
- Hinkle, L.E., & Wolf, S. (1952a). The effects of stressful life situations on the concentration of blood glucose in diabetic and nondiabetic humans. Diabetics, 1, 383-392.
- Hinkle, L.E., & Wolf, S. (1952b). Importance of life stress in the course and management of diabetes



- mellitus. Journal of the American Medical Association, 148, 513-520.
- Holloszy, J.O., Schultz, J., Kusnierkiewicz, J., Hagberg, J.M., & Ehsani, A.A. (1986). Effects of exercise on glucose tolerance and insulin resistance. Acta Medica Scandinavica, 711 (Suppl.), 55-65.
- Hornsby, W.G., Boggess, K., Lyons, T.J., Barnwell, W.H., Lazarchick, J., & Colwell, J.A. (1990). Hemostatic alterations with exercise conditioning in NIDDM. Diabetes Care, 13 (2), 87-91.
- Hull, E., Young, S., & Ziegler, M. (1984). Aerobic fitness affects cardiovascular and catecholamine responses to stressors. Psychophysiology, 21, 353-360.
- Johnson, S.B. (1990). Adherence behaviors and health status in childhood diabetes. In Holmes, C.S. (Ed.), Neuropsychological and Behavioral Aspects of Diabetes (pp. 30-57). New York: Springer-Verlag.
- Johnson, S.B. (1992). Methodological issues in diabetes research. Measuring adherence. Diabetes Care, 15 (11), 1658-1666.
- Johnson, S.B., Freund, A., Silverstein, J., Hansen, C.A., & Malone, J. (1990). Adherence-health status relationships in childhood diabetes. Health Psychology, 9, 606-631.
- Keen, H., & Jarrett, J. (1982). Complications of diabetes (2nd ed.). London: Arnold.
- Kemmer, F.W., Bisping, R., Steingruber, H., Baar, H., Hardtmann, R., Schlaghecke, R., & Berger, M. (1984). Psychological stress and metabolic control in patients with Type I diabetes mellitus. New England Journal of Medicine, 314, 1078-1084.
- Knuman, M.W., Welborn, I.A., McCann, V.J., Stanton, V.J., & Constable, I.J. (1986). Prevalence of diabetic complications in relation to risk factors. Diabetes, 35, 1332-1339.
- Kuhn, C.M., Cochrane, C., Feinglos, M.N., & Surwit, R.S. (1987). Exaggerated peripheral responsivity to catecholamines contributes to stress-induced

hyperglycemia in the ob/ob mouse. Physiology, Biochemistry, and Behavior, 26, 491-495.

Lammers, C.A., Naliboff, B.D., & Straatmeyer, A.J. (1984). The effects of progressive relaxation on stress and diabetic control. Behaviour Research and Therapy, 22, 641-650.

Landis, B., Jovanovic, L., Landis, E., Peterson, C.M., Groshen, S., Johnson, K., & Miller, N.E. (1985). Effect of stress reduction on daily glucose range in previously stabilized insulin-dependent diabetic patients. Diabetes Care, 8, 624-626.

Lawrence, R.D. (1926). The effect of exercise on insulin action in diabetes. British Medical Journal, 1, 648-652.

Leon, A.S., Connett, J., Jacobs, D.R., & Rauramara, R. (1987). Leisure-time physical activity levels and risk of coronary heart disease and death: The multiple risk factor intervention trial. Journal of American Medical Association, 258, 2388-2395.

Levi, L. (1972). Stress and distress in response to psychosocial stimuli: Laboratory and real life studies on sympathoadrenomedullary and related reactions. Acta Medica Scandinavica, 191 (Suppl. 528), 1-56.

Lloyd, C.E., Matthews, K.A., Wing, R.R., & Orchard, T.J. (1992). Psychosocial factors and complications of IDDM: The Pittsburgh epidemiology of diabetes complications study. Diabetes Care, 15, 166-172.

Marlatt, G.A., & Gordon, J.R. (1985). Relapse prevention: Maintenance strategies and addictive behavior change. New York: Guilford.

Maynard, T. (1991). Part I. Physiological responses to exercise in diabetes mellitus. The Diabetes Educator, 17, 196-204.

McCubbin, J.A., Surwit, R.S., Kuhn, C.M., Cochrane, C., & Feinglos, M.N. (1987). Effect of opiate antagonism on stress-induced hyperglycemia in obese mice. Diabetes, 36 (Suppl. 1), 18A.

- Morgan, W. P. (1985). Affective benefits of vigorous physical activity. Medicine and Science in Sports and Exercise, 17, 94-100.
- Morgan, W.P., Roberts, J.A., Brand, F.R., & Feinerman, A. D. (1970). Psychological effect of chronic physical activity. Medical Science in Sports and Exercise, 2, 213-217.
- Naliboff, B., Cohen, M., & Sowers, J. (1985). Physiological and metabolic responses to brief stress in non-insulin dependent diabetic and control subjects. Journal of Psychosomatic Research, 29, 367-374.
- National Center for Health Statistics (1980). National Health and Nutrition Examination Survey (1976-1980). Washington DC: Department of Health and Human Services.
- National Institutes of Health (1986). Diet and exercise in non-insulin-dependent diabetes mellitus. National Institutes of Health Consensus Development Conference Statement, 6(8), 1-7.
- Palmer, J.L., & McCulloch, D.K. (1991). Prediction and prevention of IDDM-1991. Diabetes, 40, 943-947.
- Physical activity and psychological benefits: A position statement from the International Society of Sport Psychology (1992). Journal of Applied Sport Psychology, 4, 94-98.
- Pohl, S.L., Gonder-Frederick, L., & Cox, D.J. (1984). An overview of diabetes mellitus. Behavioral Medicine Update, 6 (1), 3-7.
- Reitman, J.S., Vasquez, B., Klimes, I., & Nagulesparan, M. (1984). Improvement of glucose homeostasis after exercise training in non-insulin-dependent diabetes. Diabetes Care, 7, 434-441.
- Robinson, N., & Fuller, J.H. (1985). Role of life events and difficulties in the onset of diabetes mellitus. Journal of Psychosomatic Research, 29, 583-591.
- Rogers, M.A. (1989). Acute effects of exercise on glucose tolerance in non-insulin-dependent diabetes. Medical Science Sports Exercise, 21 (4), 362-368.

- Rogers, M.A., Yamamoto, C., King, D.S., Hagberg, Ehsani, A.A., & Holloszy, J.O. (1988). Improvement in glucose tolerance after 1 week of exercise in patients with mild NIDDM. Diabetes Care, 11, 613-618.
- Ruderman, N.B., Gauda, O.P., & Johansen, K. (1979). The effect of physical training on glucose tolerance and plasma lipids in maturity-onset diabetes. Diabetes, 28 (Suppl 1), 89-92.
- Schneider, S.H., Amorosa, L.F., Khachadurian, A.K., & Ruderman, N.B. (1984). Studies of the mechanism of improved glucose control during regular exercise in Type 2 (non-insulin-dependent) diabetes. Diabetologia, 26, 355-360.
- Schneider, S.H., Khachadurian, A.K., Amorosa, L.F., Clemow, L., & Ruderman, N.B. (1992). Ten-year experience with an exercise-based outpatient life-style modification program in the treatment of diabetes mellitus. Diabetes Care, 15 (Suppl. 4), 1800-1810.
- Schwartz, L.S., Springer, J., Flaherty, J.A., & Kiani, R. (1986). The role of recent life events and social support in the control of diabetes mellitus. General Hospital Psychiatry, 8, 212-216.
- Shamoon, H., Hendler, R., & Sherwin, R.S. (1980). Synergistic interactions among anti-insulin hormones in the pathogenesis of stress hyperglycemia in humans. Journal of Clinical Endocrinology and Metabolism, 52, 1235-1241.
- Shlenk, E.A., & Hart, L.K. (1984). Relationship between health locus of control, health value, and social support and compliance of persons with diabetes mellitus. Diabetes Care, 7, 566-574.
- Sinyor, D., Golden, M., Steiner, Y., & Seraganian, P. (1986). Experimental manipulation of aerobic fitness and the response to psychosocial stress: Heart rate and self-report measures. Psychosomatic Medicine, 48, 324-337.
- Skyler, J.S. (1987). Why control blood glucose? Influence on chronic complications of diabetes. Pediatric Annals, 16 (9), 713-724.

- Sothman, M.S., Horn, T., Hart, B., & Gustafson, A. (1987). Comparison of discrete cardiovascular fitness groups on plasma catecholamine and selected behavioral responses to psychological stress. Psychophysiology, 24, 47-54.
- Steiner, G. (1981). Diabetes and atherosclerosis: An overview. Diabetes, 30 (Suppl. 2), 1-7.
- Surwit, R.S., & Feinglos, M.N. (1983a). The effects of relaxation on glucose tolerance in non-insulin dependent diabetes. Diabetes Care, 6, 176-179.
- Surwit, R.S., & Feinglos, M.N. (1983b). Relaxation-induced improvement in glucose tolerance is associated with decreased plasma cortisol. Diabetes Care, 7, 203-204.
- Surwit, R.S., & Feinglos, M.N. (1988). Stress and autonomic nervous system in Type 2 diabetes: A hypothesis. Diabetes Care, 11, 83-85.
- Surwit, R.S., Feinglos, M.N., Livingston, E.G., Kuhn, C.M., & McCubbin, J.A. (1984). Behavioral manipulation of the diabetic phenotype in ob/ob mice. Diabetes, 33, 616-618.
- Surwit, R.S., Feinglos, M.N., & Scovern, A.W. (1983). Diabetes and Behavior. American Psychologist, 38 (3), 255-261.
- Trovati, M., Carta, Q., Cavalot, F., Vitali, S., Banaudi, C., Lucchina, P.G., Fiocchi, F., Emanuelli, G., & Lenti, G. (1984). Influence of physical training on blood glucose control, glucose tolerance, insulin secretion, and insulin action in non-insulin-dependent diabetic patients. Diabetes Care, 7 (5), 416-420.
- U.S. Department of Health and Human Services (1985). Diabetes in America. DHHS Publication No. (PHS) 85-1468. Washington, D.C.: U.S. Government Printing Office.
- Vandenbergh, R.L., Sussman, K.E., & Titus, C.C. (1966). Effects of hypnotically-induced acute emotional stress on carbohydrate and lipid metabolism in patients with diabetes mellitus. Psychosomatic Medicine, 28, 382-390.
- Vandenbergh, R.L., Sussman, K.E., & Vaughn, G.D. (1967). Effects of combined physical-anticipatory stress on

carbohydrate-lipid metabolism in patients with diabetes mellitus. Psychosomatics, 8, 16-19.

- Vitug, A., Schneider, H., & Rueman, N.B. (1988). Exercise and type I diabetes mellitus. In K. Pandolf (Ed.), Exercise and Sports Sciences Reviews. New York: Macmillan Publishing Company.
- Wallberg-Henriksson, H. (1989). Acute exercise: Fuel homeostasis and glucose transport in insulin-dependent diabetes mellitus. Medicine and Science in Sports and Exercise, 21, 356-361.
- Wallberg-Henriksson, H., Gunnarsson, R., Henriksson, J., DeFronzo, R.A., Felig, P., Ostran, J., & Wahren, J. (1982). Increased peripheral insulin sensitivity and muscle mitochondrial enzymes but unchanged blood glucose control in type I diabetics after physical training. Diabetes, 31, 1044-1050.
- Washburn, R.A., Smith, K.W., Jette, A.M., & Janney, C.A. (1992). The physical activity scale for the elderly (PASE): Development and evaluation. Journal of Clinical Epidemiology, 46 (2), 153-162.
- Wasserman, D.H., Lickley, H.L.A., & Vranic, M. (1983). The metabolic role of glucogen during exercise. Diabetes, 32 (Suppl. 1), 94.
- Wilson, W., Ary, D.V., Biglan, A., Glasgow, R.E., Toobert, D.J., & Campbell, D.R. (1986). Psychosocial predictors of self-care behaviors (compliance) and glycemic control in non-insulin-dependent diabetes mellitus. Diabetes Care, 9, 614-622.
- Wing, R.R., Epstein, L.H., Blaire, E., & Nowalk, M.P. (1985). Psychologic stress and blood glucose levels in nondiabetic subjects. Psychosomatic Medicine, 47 (6), 558-564.
- Wing, R.R., Epstein, L.H., Paternostro-Bayles, M., Kriska, A., Nowalk, M.P., & Gooding, W. (1988). Exercise in a behavioural weight control programme for obese patients with Type 2 (non-insulin-dependent) diabetes. Diabetologia, 31, 902-909.
- Wood, P.D., & Haskell, W.L. (1979). The effect of exercise on plasma high density lipoproteins. Lipids, 14, 417-427.

- Wredling, R.A.M., Theorell, P.G., Roll, H.M., Lins, P.E.S., & Adamson, U.K.C. (1992). Psychosocial state of patients with IDDM prone to recurrent episodes of severe hypoglycemia. Diabetes Care, 15, 518-521.
- Yeater, R.A., Ullrich, I.H., Maxwell, L.P., & Goetsch, V.L. (1990). Coronary risk factors in type II diabetes: Response to low-intensity aerobic exercise. West Virginia Medical Journal, 86, 287-290.
- Zinman, B. (1984). Diabetes mellitus and exercise. Behavioral Medicine Update, 6 (1), 22-25.
- Zinman, B., Zuniga-Guajardo, S., & Kelly, D. (1984). Comparison of the acute and long-term effects of exercise on glucose control in type I diabetes. Diabetes Care, 7, 515-519.