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The relationship of select nutrients, obesity, cardiovascular fitness, and stress on the immune function of reshape participants

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THE RELATIONSHIP OF SELECT NUTRIENTS, OBESITY, CARDIOVASCULAR FITNESS, AND STRESS ON THE IMMUNE FUNCTION OF RESHAPE PARTICIPANTS

by

Rita Charlotte Sigmon

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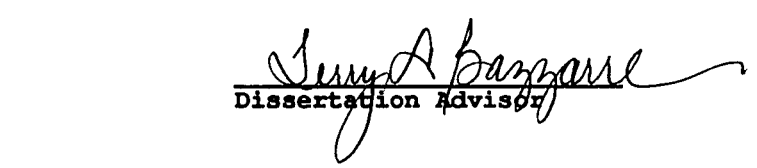

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TABLE OF CONTENTS

LIST OF TABLES

SIGMON, RITA CHARLOTTE, Ph. D. The Relationship of Select Nutrients, Obesity, Cardiovascular Fitness, and Stress on the Immune Function of Reshape Participants. (1992) Directed by Terry L. Bazzarre. 120 pp.

The purpose of this dissertation research was to evaluate the relative contribution of diet, obesity, cardiovascular fitness (CVF) and stress on three humoral components of the immune system: immunoglobulins (Igs) IgA, IgG, IgM. Forty-seven obese subjects 17 to 89 years of age; 33.6% body fat (BF) were evaluated at weeks 0 (cross-sectional component) and 12 (longitudinal component) of the Reshape program (a 12-week intervention program which promotes lifestyle management (LM) through behavior modification of dietary intake, BF composition, CVF, and stress). Participants were screened for any medical conditions known to affect immune function. Anthropometries (% BF, body mass index (BMI), waist, hip circumferences), biochemical measures (IgA, IgG, IgM, hematocrit), four-day food records, CVF (mile walk time [MWT] and exercise heart rate [EHR]), and written stress evaluations (Current Self-Appraisal [CSA], State-Trait Anxiety [STA]) were measured at weeks 0 and 12. Total energy intake (1926 $\pm$ 101 kcal) was 47% carbohydrate, 16% protein, and 36% fat, mean iron, zinc, copper, and beta-carotene intakes were below the RDA. Biochemical indices for IgA, IgG, IgM, and hematocrit were within normal ranges. In the cross-sectional study, IgM was negatively correlated with kcal ($r=-0.32$), protein ($r=-0.32$), fat ($r=-0.32$), iron ($r=-0.33$), and copper ($r=-0.33$) for the group; and with vitamin E for females ($r=-0.48$). Vitamins A, and C were positively correlated with IgA, while vitamin E was associated with IgM for males. Body weight and BMI were positively correlated with IgG, especially in females. BF was negatively correlated with IgM in females ($r=-0.36$). Both indices of CVF were positively correlated with IgM. Stress (CSA) was negatively correlated with IgA ($r=-0.38$). Weight and MWTs significantly (ANOVA;multiple regression) contributed to the variability of IgG and IgM levels, respectively, after adjusting for the effects of

age, dietary protein, and fat. BF (weight: 3.5 $\pm$ 0.7 kg; and BF: 3.5 $\pm$ 0.5%), stress, CVF (MWT: 1.2 $\pm$ 0.2 minutes), and dietary fat intake all changed favorably among Reshape participants. Changes in hip circumferences and BF were significantly related to changes in IgA ($r=-0.34$) and IgG ($r=0.41$), respectively. Increased happiness (CSA) was positively correlated with IgA changes ($r=0.50$). IgG (paired-differences t-test) significantly decreased among males (139.8 $\pm$ 65.1 mg/dl). Large variations in Ig levels coupled with controlled, non-stress inducing behavior modification techniques of the Reshape program contributed to the lack of significant overall changes in Ig levels. Future research is needed to establish normal response patterns for Igs.

CHAPTER I

INTRODUCTION

The 1980s heralded new directions for personal health. For the first time, individuals became involved in the development of their own program for self improvement. A program of this nature involves a multifaceted approach which addresses the modification and or improvement of factors that have been identified by health professionals as potential health concerns. This system of personal involvement of multifaceted health behavior modification is called lifestyle management.

Lifestyle management has evolved from a meager beginning when people realized that exercising was not just for athletes. Cardiovascular exercise became an important part of daily routines. Several years into the jogging/fitness era, health professionals realized that exercise alone will not solve all health related problems. The quality of health in life is affected by the interplay of numerous factors. Nutrient intake, weight control, and stress management combined with appropriate cardiovascular fitness are the four essential components of lifestyle management.

Health professionals postulate that if one practices a healthy lifestyle, that both the quantity and quality of life can be enhanced. Preventing and or minimizing the debilitating and aging effects of illness is paramount to life. The latin word "immunis", meaning free from burden, is the name given to the immune system which is responsible for maintaining a disease free state in humans. The immunosurveillance system plays a vital role in host resistance to a disease-free state, yet is affected by other body systems as well as other factors in the

environment. Scientists have yet to fully understand specific means of increasing longevity and quality in life.

The immune system is an intricate complex which functions in many still yet to be discovered ways. An overview of the literature indicates that the research to date is quite sparse and diversified, with no known studies addressing the impact of behavior modification program constitutents on immunoglobulins.

Nutritional deficiencies as well as excesses can affect various components of the immune system (Chandra, 1988). Epidemiological data suggest that vitamin A enhances resistance to cancer (Watson, 1986). Increased beta-carotene intake is inversely associated with cancer risk (Chandra, 1988). Vitamin C, known for its antioxidant capacity, is highly concentrated in leukocytes (Moser & Weber, 1984). Researchers postulate that the antioxidant characteristics of vitamin C may be of importance as an immunostimulatory agent.

Clinical, epidemiological, and experimental studies have shown conflicting information regarding the relationship of infection, impaired immune function and iron deficiency (Chandra, 1988). The reversal of altered cellular immune response in individuals who have infections following supplementation suggests the possibility of clinically significant benefits of nutrition on immune function.

Alford (1970) was one of the first researchers to discover that zinc was an important factor which indirectly affected human lymphocyte blastogenesis. The role of zinc on immune function is well established. Zinc affects cellular reactions, surface interactions, lymphocyte subpopulation expansion, signal transmission, and network regulation (Chandra, 1988).

Numerous immune functions are affected by dietary fats (Chandra, 1988). Circulating lipoproteins, stimulation of specific cell subsets and membrane properties, changes in eicosanoid synthesis, and altered receptor sites and numbers are affected by dietary fats. Barone and

Hebert (1989), in one of very few human studies involving the direct measurement of a nutrient-immune component, found that lowering the fat intake to 20% of total calories significantly increased the NK-cell activity of 17 non-obese men.

Obesity in adolescents may be associated with impaired immune function. Chandra and Kutty (1980) found that 38% of the obese group (n=28) had impaired cell-mediated in vivo and in vitro immune responses. Obese subjects on a controlled starvation diet (Wing & Stanko, 1983) produced significantly higher monocyte, natural killer cell activity, and IgA, IgG, IgM levels compared to pre-treatment measures.

The human body responds to stress in a variety of ways. Of principal interest is the effect of increased cortisol levels on different immune components. Active people do not exhibit the exercise-related increase in glucocorticoids observed among their sedentary counterparts (White & Ismail, 1976). Increased cortisol and PMN leukocytes were found by Moorthy and Zimmerman (1978) in endurance runners. However, lymphocyte count did not change. Interleukin production is in part regulated by corticosteroids (Watson, 1989). Thus, scientists are interested in determining how exercise stress affects other components of the immune system.

The general consensus of most runners, joggers, and other physically active people is that they are healthier than the general population (Simon, 1984). Three different epidemiological studies (Garabrant, Peters, Mack, & Berstein, 1984; Gerhardson, Norell, Kiviranta, Pedersen & Ahlbom, 1986; Vena, Graham, Zielezny, Brasure, & Swanson, 1987) involving males, their level of physical activity, and the incidence of colon cancer produced similar findings. In all three investigations, there was an increased risk of colon cancer among subjects with light physical activity or sedentary occupations. Frish et al (1985) surveyed 5,398 women and found that those who were athletes in college had a consistently lower prevalence of cancers of the female

reproductive organs. The long term effects of daily physical activity on the immune system component of individuals is virtually unknown.

Emotional or psychological stress also affects immune function. Irwin (1987) has shown that there is an interrelationship between physiological stress, altered brain functions and their combined effect on the immune system via reduced natural killer cell activity.

Significance of Research

This dissertation research represents an effort to evaluate the relationship of four lifestyle management factors (diet, body fat, cardiovascular fitness, and stress) to the humoral branch of the immune system (immunoglobulins: IgA, IgG, IgM). Due to the difficulty of isolating one variable while using the human research model, these variables were examined before and after participation in the Reshape program. Information gathered as a result of this study represents one of the first attempts to establish a relationship between several components associated with chronic disease processes, and to equate them directly with specific measures (immunoglobulins) of immune function.

Purpose of the Investigation

The purpose of this research proposal was to evaluate the relative contribution of diet, obesity, measures of cardiovascular fitness and stress on immunoglobulins IgA, IgG, and IgM.

Hypotheses

The Reshape population is a cross-section of people varying in age, occupation, ethnicity, dietary habits, cardiovascular fitness, and stress. This research project consists of a cross-sectional and a longitudinal component. Data were collected at weeks 0 and 12 of the Reshape program. Week 0 data was used for the cross-sectional evaluation. Hypotheses H: 1 through H: 5 address the cross-sectional component of this dissertation. The longitudinal component of this dissertation research is addressed by comparing week 0 (beginning) with week 12 (end) data (i. e., intervention effect or impact of Reshape

program). Hypotheses H:6 through H:19 address the longitudinal component of this dissertation.

CROSS-SECTIONAL STUDY

What Is The Relationship Between Immunoglobulins and Lifestyle Management Components?

Only the data from week 0 will be used to test the following hypotheses:

H:1 There will be an association between immunoglobulins IgA, IgG, IgM and diet (kilocalories; carbohydrate; protein; percent kilocalories, carbohydrate, protein, fat; vitamins, A, C, E, and beta-carotene; and iron, zinc, and copper.

H:2 There will be an association between measures of obesity and immunoglobulins IgA, IgG, and IgM.

H:3 There will be an association between measures of cardiovascular fitness and immunoglobulins IgA, IgG, and IgM.

H:4 There will be an association between measures of stress and immunoglobulins IgA, IgG, IgM.

H:5 A significant amount of the variabiltiy in the immunoglobulin levels will be explained by the selected components of lifestyle management.

LONGITUDINAL STUDY

Data from both weeks 0 and 12 (change variables or mean differences) will be used to test the following hypotheses:

Intervention or Reshape Program Impact

H:6 Reshape participants will weigh less at week 12 than at week 0.

H:7 Reshape participants will have less body fat at week 12 than week 0.

H:8 Stress measures of Reshape participants will improve from week 0 to week 12.

H:9 Measures of cardiovascular fitness will improve from week 0 to week 12.

H:10 Reshape participants will reduce their dietary intake of fat.

H:11 Reshape participants will increase their dietary intake of vitamins A, C, and E as well as beta-carotene.

H:12 Reshape participants will increase their dietary intake of iron, zinc, and copper.

What is the Relationship between Immunoglobulin Changes and Changes in the Lifestyle Management Components?

Dietary

H:13 A reduction of dietary fat intake will be associated with changes in IgA, IgG, IgM.

H:14 Changes in dietary intakes of vitamins A, C, and E and beta-carotene will be associated with changes in IgA, IgG, IgM.

H:15 Changes in dietary intakes of iron zinc, and copper will be associated with changes in IgA, IgG, IgM.

Body fat

H:16 A reduction of body fat measures will be associated with changes in IgA, IgG, and IgM.

Cardiovascular Fitness

H:17 Changes in measures of cardiovascular fitness will be associated with changes in IgA, IgG, IgM.

Stress

H:18 Changes in measures of stress i.e. Recent Events Inventory,

Current Self-Appraisal, and State-Trait Anxiety Inventory will be associated with changes in IgA, IgG, IgM.

H:19 Immunoglobulins levels of Reshape participants will change from week 0 to week 12.

Definitions

Cross-sectional study: Examination of variables across all members of the population at a given time.

Longtitudinal study: Examination and comparison of variables (of a population) before and after the intervention (Reshape program).

Mitogens: Provocative stimuli causing cell proliferation within the immune system. Examples of mitogens: Concanavalin A (ConA), phytohemagglutinin (PHA), and lipopolysaccharide (LPS).

BMI: Body mass index. Weight (in kilograms) divided by height^2 (in meters).

Percent Body Fat: measurement of body fat expressed as a percent of total body weight estimated from the sum of four skinfolds (Durnin & Womersley, 1973).

Normal body weight: BMI; < 25 kg-m^2, Percent body fat: < 20 for males, < 22 for females (Gibson, 1990).

Overweight or overfat: BMI; 25-29.9 kg-m^2, Percent body fat; 20-28 for males, 22-30 for females (Gibson, 1990).

Obese: BMI; $\geq$ 30 kg-m^2, Percent body fat; > 28 for males, > 30 for females (Gibson, 1990).

CHAPTER II

REVIEW OF LITERATURE

The focus of this review is on the relationship between lifestyle management components (selected nutrients, obesity, cardiovascular fitness, and stress) and the human immunosurveillance system. A general overview of the human immune system will be discussed before reviewing the relevant literature.

OVERVIEW OF THE IMMUNE SYSTEM

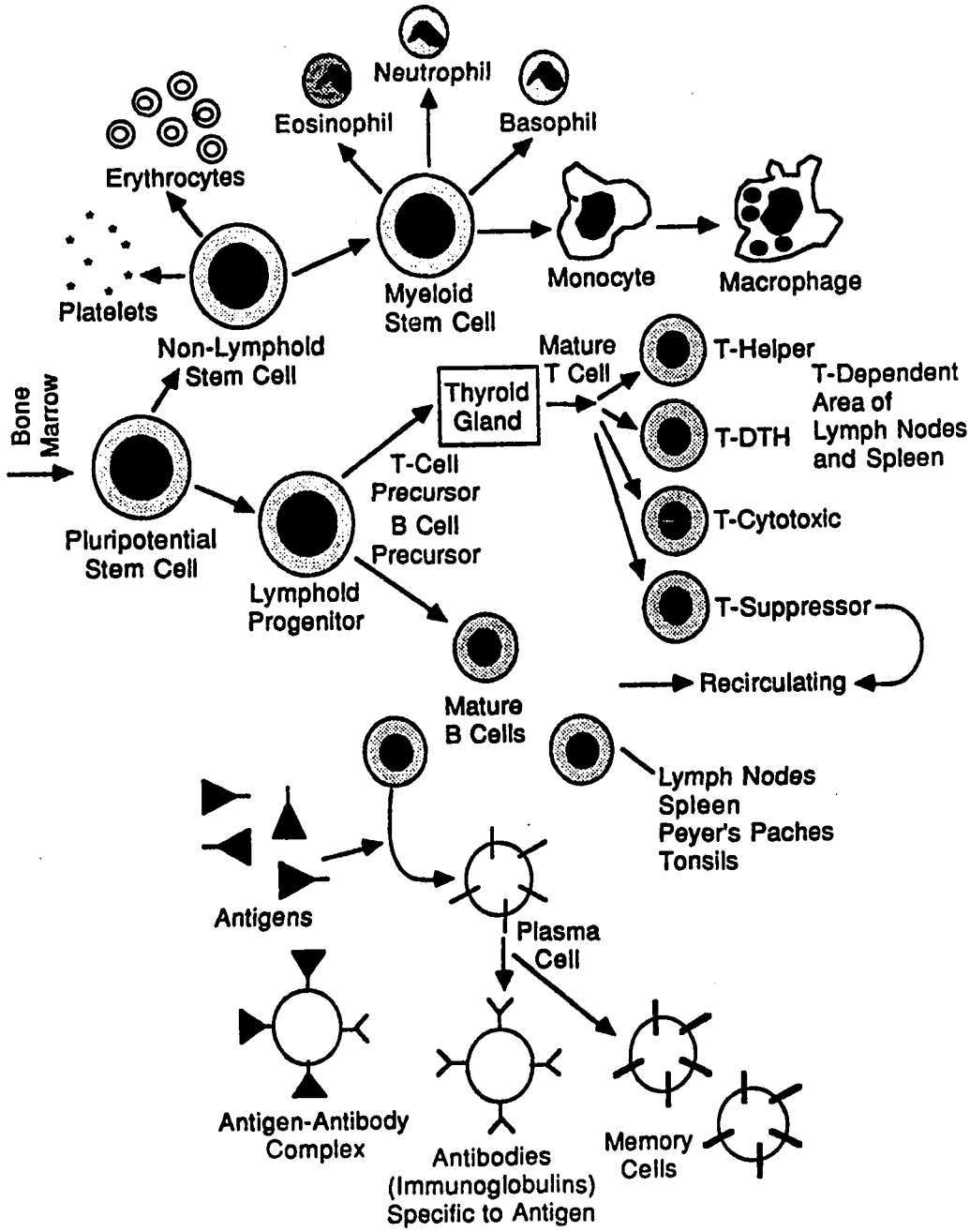
The source of all immune cellular components can be traced back to the bone marrow where pluripotential stem cells are produced (Benjamini, 1988). Figure 1 graphically depicts the theoretical immunosurviellance components of the immune system beginning with the bone marrow.

Stem cells differentiate into two different classes, non-lymphoid stem cells and lymphoid progenitors. Non-lymphoid stem cells can give rise to any one or combination of the three following cells: platelets, erythrocytes (red blood cells), or leukocytes (white blood cells). Leukocytes can then develop into polymorphonuclear leukocytes (PMNs or granulocytes), eosinophils, neutrophils, basophils, or monocytes. Monocytes circulate in the blood. Monocytes that migrate to a specific tissue site are then called macrophages. The monocyte class acts to attach and engulf foreign material.

Lymphoid stem cells give rise to T-cells and B-cells. T- and B-cells are so named due to the mediating site of these cells; thymus and bone marrow. T-cells give rise to T-helper, T-DTH, T-cytotoxic, and T-suppressor cells. T-cells are capable of secreting a variety of hormones known collectively as cytokines (ex:interferon, interleukins) (Calabrese, 1988). T-cells can also produce natural killer cells, which can kill certain tumor cells and infectious substances. Cytokine

Figure 1

Differentiation of the Stem Cell: Immunosurveillance Components



influence on NK cells has been associated with a type of anticancer cancer defense involving patients with metastatic cancer (Rosenberg et al, 1985). T-cells also play a key role in cell mediated immune response (CMI).

Mature B-cells differentiate into plasma cells upon exposure to an immunogenic substance. Once exposed, the plasma cell can synthesize and secrete specialized antibodies also known as immunoglobulins. Concurrently, some of these sensitized plasma cells revert to resting B-cells. These resting B-cells are called memory B-cells. Memory B-cells play a key role in future immunity to that immunogen.

A specific antibody produced by the plasma cell is located on the surface of the plasma cell. This surface marker is a "matching fit" and is capable of binding to an immunogen. There are five classes of antibodies or immunoglobulins produced: IgA, IgG, IgM, IgD, and IgE.

Descriptive biochemical and physiological information (Bellanti, 1985; Benjamini, 1988; Goodman, 1987; Sinnett, 1983; Tizard, 1989) for each of the three immunoglobulin classes (IgA, IgG, IgM) are found in Figure 2. Binding of a specific immunoglobulin to an immunogen may involve another component of the humoral (B-cell lineage) system known as the complement system. Activation of the complement system may involve the recruitment of PMNs. PMNs play a vital role in the eventual destruction of the immunoglobulin and its attached immunogen.

A blood-borne antigen will by chance usually encounter PMNs such as neutrophils. Additional help in antigen processing is recruited via the PMN's release of a chemotactic factor. Macrophages may engulf the antigen, with subsequent display of the antigenic markers. Macrophages are capable of secreting any of the following products: macrophage activating factor, interferons (IF), interleukins (IL), and prostaglandins (PG). T-helper cell processing of the antigen results in the release of B-cell growth factor, B-cell differentiation factor, and IL-2 secretion. The B-cell responds after T-helper interaction by

Figure 2

Physiochemical Properties and Biologic Functions of Immunoblobulins

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IgA:

Little is known about role/function of serum IgA. Maternal transfer of IgA occurs via colostrum. Precursers to secretory IgA are found in lumens of the body (i.e., parotid glands, intestinal villi. Secretory IgA is found in saliva, tears, nasal and bronchial secretions, and gastrointestinal tract.

Molecular weight: 160,000; mean serum concentration: 200 mg/100ml; L chain type: kappa and lambda; biologic half-life: 6.7 days; percent of intravascular pool catabolized per day: 25; antiviral activity: +++.

IgG:

Antitoxin, antibacterial, antiviral. Neutralizes toxins, viruses in blood stream, tissue spaces, recruitment not directly phagocytoxic, and is transferred via placenta.

Molecular weight: 148,000; mean serum concentration: 1210 mg/100ml; L chain type: kappa and lambda; biologic half-life: 23 days; percent of intravascular pool catabolized per day: 6.8; antiviral activity: +.

IgM:

Antipolysaccharide and anti-Gram negative bacteria, heterophile antibodies. Pentamer, stays in intravascular spaces, 700-1000x as efficient as IgG in agglutinating a red blood cell or bacterium, first Ig to appear in phylogeny and ontogeny and last to leave in senesence.

Molecular weight: 1,000,000; mean serum concentration: 135 mg/100ml; L chain type: kappa and lambda; biologic half-life: 5 days; percent of intravascular pool catabolized per day: 18; antiviral activity: +.

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making the appropriate antibody class switch. Unsensitized B-cells have IgM and IgD antibodies. IgM production is the primary antibody response. If a secondary response occurs, an appropriate antibody class switch to IgG (usual response), IgA or IgE occurs. Lysis of the antigen/antibody complex can occur via activation of the complement cascade system. T-suppressor cells are one of many interactive methods of stopping a antibody mounted immune response.

Natural killer (NK) cells, interleukins (IL) and prostaglandins (PG) are adjunct immune functions. Natural killer cells are capable of attacking foreign material, chemically altered or cancerous cells without B-cell involvement. Interferon or IL-2 can activate NK cell activity. Fever and inflammation are two common responses created by ILs. Fever plays an important role in the immune response, for it slows viral replication and enhances the complement cascade response. Prostaglandins are derived from membrane fatty acids and serve to mediate local immune response. Macrophages can modulate PGs to terminate an immune response.

A host of factors can affect the immune system. The following variables and their respective known effect upon the human immunosurveillance system will be discussed: general heredity; age and gender; select nutrient intakes: energy, protein, fat; vitamins A, beta-carotene, C, E; iron, zinc, and copper; obesity; exercise; and stress.

GENERAL HEREDITY

Coding for the immune system is present in the genes as are all other characteristics representative of one's ancestral contributions to the offspring. Defects, if present, usually involve a single gene which is associated with cellular histocompatibility. Autoimmune diseases such as rheumatoid arthritis result when a component of the "self" is treated by the immune system as an immunogen (Bellanti, 1985; Benjamini, 1988).

AGE AND GENDER

The immune system is basically the same, in both sexes. It is possible to have a sex-linked chromosomal defect coding for an autoimmune disease. Systemic lupus erythematosus occurs more commonly in females, especially Afro-Americans (Bellanti, 1985).

Pluripotential stem cells originate in the fetal liver and eventually migrate to the bone marrow. However, the immune system is immature and relies upon passive immunity from the mother. Placentally transferred maternal IgG occurs until birth (Johnson, 1989). Breast milk, especially colostrum may contain a variety of factors, including IgA, which help protect the infant (Tomasi & Ccerwinski, 1968). The infant's immune system does not completely develop until childhood (10-12 years old) (Bellanti, 1985). In general, the immune system is impaired due to immaturity before age (10-12 years) and in older individuals due to an overall decrease in physiological function (Winchurch, 1987). As an individual ages, so does the immune system. The thymus steadily atrophies with age; with resulting associated changes through controls over other body functions. The humoral response is altered due to a decrease in the number of T-helper cells (Schorah, Tormey & Brooks, 1981). Hallgren, Jackola and O'Leary (1983) reported that despite no change in the total B-lymphocyte production and number, the serum IgM concentration decreased whereas levels of IgA increased. Immunocompromization in the elderly population may be due to fewer T-helper cells.

NUTRITION AND IMMUNE FUNCTION

Nutritional deficiencies as well as excesses can affect various components of the immune system. Protein-calorie malnutrition and infection go hand in hand. Undernutrition worldwide, especially in the third world countries, is the most common cause of impaired immune function (Chandra, 1981). Undernutrition today is also present among hospitalized patients, underweight infants and the elderly (Chandra,

1988). Gross and Newberne (1980) cite 52 different studies which address the impact of PCM on serum immunoglobulins, stating that "In general, studies of IgG, IgM, and IgA levels present a scatter of values so wide that one can conclude only that these immunoglobulins are either normal or increased in PCM." The severity and duration of protein calorie malnutrition determines the extent of its effect on both the humoral and cell mediated responses. Proper nutrition rectifies the impaired immune response; often, long before weight is gained. In fact, (Chandra, 1988) suggests that indices of immune function be used as diagnostic tools for nutrition assessment.

DIETARY FAT AND IMMUNE FUNCTION

Numerous immune functions are affected by dietary fats (Chandra, 1988). Circulating lipoproteins, stimulation of specific cell subsets and membrane properties, changes in eicosanoid synthesis, and altered receptor sites and numbers are affected by dietary fats. Eicosanoids may serve as communication links between cellular and humoral immune functions via conversion to prostaglandins and leukotrienes (Van Buren & Gottschlich, 1990). High dietary intakes of omega-6 polyunsaturated fatty acids (PUFAs) are associated with enhanced tumor growth (Chandra, 1988) via PGE_2's mediating effect of inhibiting T-cell reproduction. Barone, Hebert and Reddy (1989), in one of very few human studies involving the direct measurement of a dietary-immune component, found that lowering the fat intake to 20% of total calories significantly increased NK-cell activity of 17 non-obese men. A study by Pearce and Dayton (1971) addressing the incidence of atherosclerotic deaths of men (8 year clinically controlled) fed diets high in PUFAs and low saturated fats reported that deaths due to cancer in the experimental group were higher than the control group ($p=0.06$).

VITAMIN A AND BETA-CAROTENE

Epidemiological data suggest an important role for vitamin A in cancer resistance (Watson & Leonard, 1986). Ironically, relatively

little is known about vitamin A deficiency and immune function in man, except in association with severe PCM. Decreased antibody response has been observed among animals with vitamin deficiencies. Bang, Foard and Bang (1973) reported enhanced cell-mediated and humoral immune responses with the use of non-toxic levels of vitamin A fed to vitamin A deficient chickens. Atrophied states of the thymus and bursa of Fabricius were common in vitamin A deficient chickens. The role of vitamin A in assisting NK cell activity was elucidated in a study using athymic nude mice who have no T-cells (Fraker, Halter & Forves, 1986). NK cell activity significantly ($p=0.005$) increased (up to 70%) in non-nude mice after vitamin A supplementation equal to 600 ug/day. The nude mice showed no change in NK cell activity. The lack of response by the athymic BALB/c mice may be attributed to the role of T-cells in NK cell activity. Retinol may be of value in early tumor prevention because of its ability to directly affect NK activity before antigen dependent T-cells have been produced. Vitamin A appears to ameliorate both T and B-cell functions in severe burn patients (Van Buren & Gottschlich, 1990).

Elevated beta-carotene intake via vegetables is inversely associated with cancer risk (Chandra, 1988). Beta-carotene may exert an anti-tumorigenic effect independently of vitamin A. Canthaxanthin is a carotenoid which cannot be converted to vitamin A in mice. Bendich and Shapiro (1986) found that mice fed beta-carotene exibited enhanced T and B-cell blastogenesis to mitogens ConA, PHA, and LPS while the canthaxanthin group showed no change.

VITAMIN C

Vitamin C is known for its antioxidant capacity. Use of animals in vitamin C studies are quite limiting in their applicability to the human model, as only guinea pigs and monkeys share man's inability to synthesize vitamin C. Since the concentration of vitamin C is high in leukocytes (Moser and Weber, 1984), researchers postulate that this factor combined with its antioxidant abilities may be important as an

immunostimulatory agent.

Anderson, Oosthuizen, Maritz, Theron & Van Rensburg (1980) fed supplemental vitamin C (1, 2, or 3 grams) to humans without any change in IgA, IgG, IgM, C'3 and C'4 serum levels. Manzella and Roberts (1979) examined *in vitro* response of human mononuclear leukocytes to PHA while varying conditions using vitamin C and influenza virus. The equivalent concentration of vitamin C that was used was 2 mg/100ml. Viral exposed PMN response to PHA was significantly ($p \leq 0.02$) depressed compared to control PMN response (4,184 c.p.m. vs 11,276 c.p.m.). Ascorbate exposed PMN response to PHA was enhanced significantly ($p \leq 0.02$) compared to the control response (16,033 c.p.m. vs 11,275 c.p.m.). When ascorbic acid was added to PMNs already exposed to the virus, the response was almost equal to the PHA stimulated control response (9,172 c.p.m. vs 11,276 c.p.m.). The presence of vitamin C significantly ($p \leq 0.005$) enhanced PHA's response compared to the response from virus exposure by itself (9,172 c.p.m. vs 4,184 c.p.m., respectively). Ascorbic acid alone (in absence of PHA) was not mitogenic to PMNs.

Histamine is known to promote T-suppressor cell activity, thus potentially inhibiting lymphocyte proliferation. *In vitro* vitamin C (10^{-8} to 10^{-5} M) inhibits histidine decarboxylase and, hence, histamine formation in male ODS-od/od rat spleen cells (Oh & Nakano, 1988). This species can not synthesize vitamin C.

VITAMIN E

Vitamin E is the major antioxidant component of lipid membranes, therefore offering protection from free-radical generated chain reactions at the cellular site. A vitamin E level of 476 mg of all-rac-alpha-tocopheryl acetate per kilogram body weight fed to lambs significantly ($p=0.05$) enhanced primary antibody concentrations when compared to lower doses of vitamin E. There were no significant differences between the dosage levels based on the secondary antibody response (Ritacco & Nockles, 1986). Hemodialysis patients deficient in

vitamin E have increased peripheral blood mononuclear cell membrane damage. Alpha-tocopheryl acetate (300 mg/day) supplementation improved membrane integrity, but did not significantly increase vitamin E membrane concentrations. T-cytotoxic-suppressor numbers significantly ($p=0.006$) decreased 20% after supplementation. T-helper cells increased 4% (non-significant). T-helper/T-suppressor ratio significantly ($p=0.004$) increased 35% (Taccone-Gallucci, Giardini & Ausiello, 1986). Vitamin E appears to exert it's effect by suppressing PGE_2 synthesis. PGE_2 activity is immunosuppressive toward T-cell activity (Van Buren, Gottschlich, 1990).

IRON

Clinical, epidemiological, and experimental studies have produced conflicting information regarding the relationship of infection, impaired immune function, and iron deficiency (Chandra, 1988). Transferrin is the primary carrier protein for iron. When macrophages are activated, transferrin receptors are expressed on their surface (Hamilton, Weiel & Adams, 1984). Iron is also a cofactor for ribonucleotide reductase; essential for DNA synthesis. Iron deficiency has been associated with changes in: chemotactic activity of neutrophils, total lymphocyte number, delayed hypersensitivity, and production of macrophage inhibitory factor. Joynson, Walker, Jacobs and Dolby, (1972) showed delayed skin hypersensitivity to candida antigen in 9 of 12 iron deficient subjects, whereas all 12 controls reacted normally. Thymidine uptake (DNA synthesis of lymphocytes) was significantly ($p=0.001$) impaired in iron-deficient subjects (controls, 22.26 vs iron deficient, 7.73 mean c.p.m. x $10^3/10^6$ lymphocytes). Macrophage migration inhibition factor differed significantly ($p=0.005$) between controls and iron deficient subjects using candida antigen (controls, 3.32 vs iron deficient, 1.16). MacDougall, Anderson, McNab and Katz (1975) found no significant difference between 20 South African children with iron deficient anemia and 14 controls for immunoglobulins

IgA (including salivary IgA), IgG, and IgM. Seventy-five percent of the anemic children had been on antibiotics 7-10 days prior to testing. There was a non-significant increase in total lymphocytes number. Neutrophil chemotactic activity of anemic children significantly ($p=0.05$) increased in chemotaxis to self-endotocin-activated serum compared to the control children's response to their own serum. Lymphocyte transformation (as measured by thymidine uptake for DNA synthesis) was significantly ($p=0.02$) impaired in anemic children (control 13.37 vs anemic 9.74). On the other hand, excesses of iron (due to chronic transfusion therapy) as witnessed by thalassemia patients does have a significant effect by decreasing ($p=0.001$) NK cell cytotoxicity (Akbar, Fitzgerald, De Susa, Giardina, Hilgartner & Grady, 1986). The decrease in NK activity could not be attributed to a decrease in NK cell number.

ZINC

Alford (1970) was one of the first researchers to discover that zinc, when reintroduced in vitro, partially restores the ability of human lymphocytes to proliferate in response to a mitogen. The role of zinc in immune functions is well established (Sherman & Hallquist, 1990). Zinc affects cellular reactions, surface interactions, lymphocyte subpopulation expansion, signal transmission, and network regulation (Chandra, 1988). Inability to form oxygen radicals by phagocytes (Weiss & LoBugkio, 1982) and impaired memory cell capabilities (DePasquale-Jardieu & Fraker, 1984) have been documented in zinc deficient mice.

COPPER

Copper's role in immunoregulation is not completely understood. Quaternary structures of the immunoglobulins are dependent in part on copper (Chandra, 1988). C16 and C18 fatty acid metabolism was altered (Fell, Dinsdale & Mills, 1975), but not PGE_2 level (Koller & Mulhern, 1988) with copper deficiency. Copper deficient infants recovering from

marasmus experienced fewer respiratory tract infections when supplemented with copper (80 ug/kg/day) (Castollo-Duran, Fisberg, Vanlenzuela, Egana & Uauay, 1983).

OBESITY

Obese individuals may have impaired resistance to infection. Meares (1975), in an article reviewing factors that influence surgical wound infections, compared incidences of postoperative wound infection between the obese (18.1%) and non-obese (7.1%) (Rhoades, 1964). Another study by Cruse and Foord (1973) showed similar differences in developed wound infections; obese (13.5%) and non-obese (1.8%).

Chandra and Kutty (1980) found that a group of 28 adolescents 20% overweight had impaired cell-mediated immunity but normal IgG, IgA, and IgM levels. These same subjects had a significantly ($p=0.05$) higher incidence of iron (13% vs 27% mean transferrin saturation,) and zinc deficiency (8.3 umol/L vs 13.2 umol/L mean plasma zinc) than the control group. Low zinc levels have been frequently observed in obese individuals regardless of their age.

Fifteen obese subjects (Wing & Stanko, 1983) were on a controlled starvation diet of 80 kcal/day for two weeks. Monocyte and natural killer cell activity were significantly enhanced. Serum IgG (19%), IgA (22%), and IgM (16%) levels were significantly increased ($p=0.01$). Although this study design very closely duplicates protein-calorie malnutrition (decreased protein and kilocalorie intake), these findings are in contrast with poor immune responses associated with chronic PCM (Gross & Newberne, 1980). PCM is associated with decreased NK cell activity, and decreased circulating interferon levels (Salimonu, Ojo-Amaize, Williams, Johnson, Cooke, Adekunle et al, 1982). Immunoglobulin levels in patients with PCM are frequently increased, possibly due to chronic infections (Chandra, 1988).

EXERCISE

The general consensus of most runners, joggers, and other

physically active people is that they are healthier than the general population (Simon, 1984). Paffenbarger (1986) compared the physical activity level of 16,936 college alumni with the all causes for mortality. A consistent ($p=0.0001$) decrease in deaths was found as the level of physical activity increased from less than 500 kcal to 2,000 plus per week. The trend was consistent across all age groups. Three different epidemiological studies (Garabrant, Peters, Mack, & Berstein, 1984; Gerhardsson, Norell, Kiviranta, Pedersen & Ahlbom, 1986; Vena, Graham, Zielezny, Brasure, & Swanson, 1987) involving males, their level of physical activity and the incidence of colon cancer produced similar findings. In all three investigations, there was an increased risk of colon cancer among populations with light physical activity or sedentary occupations. Frisch et al (1985) surveyed 5,398 women and found that those women who were athletes in college had a consistently lower prevalence of cancers of the female reproductive organs than their non-athlete counterparts. Relative risk (non-athletes/athletes) was 2.53 for reproductive system cancer and 1.86 for breast cancer. Analyses controlled for confounding variables such as age, familial cancer, oral contraceptive use, smoking, and leanness. Richter (1991) found no changes in the T-helper, T-suppressor, NK cells, or monocytes of eight endurance athletes after six weeks each of a high animal protein versus a lacto-ovarian diet. There was a four-week wash-out ad libitum dietary period between trials. The energy distribution of both trial diets was 57% carbohydrates, 29% fat, and 14% protein.

The long-term effects of daily physical activity on the immune system component of individuals is virtually unknown. A group ($n=46$) of young, inactive males (mean body fat=18.3%) were trained aerobically for 15 weeks (Watson et al, 1986). Training did not significantly affect the percentage of total lymphocytes isolated. The number of mature T-lymphocytes increased significantly (65% before vs 74% after training; $p=0.05$). Natural killer cell activity significantly decreased (38.8%

pre-training vs 29.3% post-training; (p=0.01). Tchorzewski, Denys, and Zytkiewicz (1976) compared PMN leukocyte functions of two groups of 16 year old boys after a period of 6 years. Polymorphonuclear leukocyte lysome (PMNL) enzyme levels were significantly lower (p=0.02, 0.01, 0.01, respectively) for acid phosphatase and protease, and neutral protease in the boys who were in intense sport training compared to the controls.

Several studies have attempted to measure selected components of immunity using athletes involved in short term exercise bouts. Hanson & Flaherty (1981) found no adverse effect on the cellular or humoral components of 6 well-conditioned male runners before and after an 8-mile training run. Twenty male marathon runners (6 of them "world class") showed normal leukocyte phagocytosis and killing as well as normal values for quantative immunoglobulins (IgG, IgA, IgM). Nine of these runners subjectively felt that long distance running increased their resistance to respiratory infections, whereas only one felt the opposite way (Green, Kaplan, Rabin, Stanitski, & Zdziarski, 1981). Tomasi, Trudeau, Czerwinski, & Erredge (1982) age-matched controls to 5 male and 3 female nordic skiers. Parotid salivary secretory IgA levels, the percentage of B-lymphocytes, and the null population (non-T,non-B) lymphocytes were measured and compared with the controls. Serum immunoglobulins were measured but not reported. Salivary IgA levels were significantly lower (p=0.05) among the skiers compared to control subjects before the race (controls, 3.93 mg/100 mg protein vs skiers, 1.46 mg/100 mg protein). The skiers' IgA values dropped even lower after the race. The mean percentage of B-lymphocytes was significantly higher in the athletes (24%) compared to the controls (13.8). Parotid IgG levels were not significantly different between the two groups at any point. Plasma corticosteroid levels of the skiers (25.6 ug/dl) were elevated above expected levels for the time of sampling. Several circumstances may have attributed to the lower immunoglobulin levels,

i.e., lowering of the mucosal temperature, depletion of nasal fluid during competition, and the overall stress involved with international travel and competition.

MacNeil (1991) examined lymphocyte proliferation (response to ConA) in response to acute exercise; comparing three fitness levels (low, moderate, and a no-exercise control group). There were 64 subjects in each group. Lymphocyte proliferation was expressed as the rate of radiolabeled thymidine uptake in counts per million ([^{3}H]TdR). The lowest point of decreased lymphocyte response occurred (in all three exercise groups) two hours post exercise. Lymphocyte response approached baseline values at 24 hours post exercise. The low fitness group lymphocyte proliferation response (overall mean of 35 x 10^{-3} c.p.m.) was significantly lower ($p=0.05$) than the control group (approximately 60 x 10^{-3} c.p.m.). Although non-significant, lymphocyte response to increasing exercise intensity inversely declined with the group fitness level (i. e. the higher the group's fitness level, the lower the proliferation response). Plasma cortisol levels between the groups were significantly different ($p=0.05$). Overall cortisol response increased immediately post exercise followed by a return to or slightly below baseline level at 2 hours post exercise. The 24 hour and immediate pre-exercise average cortisol levels and [^{3}H]TdR uptakes of the low fitness group (18.0 ug/dl, 39,937 c.p.m.) were significantly lower ($p=0.05$) than the control group (15.1 ug/dl, 60,852 c.p.m.). However, there was no overall pattern of correlation between cortisol responses and [^{3}H]TdR uptake between any of the groups.

White (1976) examined the corticosteroid response of an active and a sedentary group in response to a four month fitness program. Serum cortisol levels of both groups were significantly higher during high intensity work loads and during recovery. Individuals in the sedentary group had a sustained significant ($p=0.01$) increase in cortisol levels throughout, including the recovery period. Beta-adrenergic medications

were suspected of affecting lymphocyte function. Watson et al (1986) ruled out the effects of beta-adrenergic blockers on NK cells, and the number of mature T-lymphocytes of unconditioned males (n=46) undergoing a 15- week training program. NK cell activity decreased (p=0.01) in all groups (pre- vs post training). NK cell activity expressed as % lysis of K-562 tumor cells were pre- vs post: placebo group, 38.8 vs 29.3; propranolol 35.0 vs 23.5; and atenolol group, 32.6 vs 26.7. There was no change in the percent of total lymphocytes due to training or to beta-blockade. Neiman et al (1991) and Nehlsen-Cannarella, Nieman, Jessen et al (1991) examined the immune functions of 12 mildly obese women undergoing an acute 45 minute walking exercise session at 60% VO2. Significant differences were found between the patterns of change between the two conditions (exercise vs. resting) for IgA and IgG (p=0.001) and IgM (p=0.01). IgG increased 7.2% post exercise, but returned to baseline. The pattern of change created by PHA stimulated lymphocyte proliferation was not significantly different (p=0.05 level) between exercise and resting conditions. However, a single significant drop in lymphocyte proliferation occurred with exercise (16 x 10^3 c.p.m.) 1 1/2 hours post exercise when compared to baseline resting (30 x 10^3 c.p.m.) and baseline exercise levels (36 x 10^3 c.p.m.). Subsequent measures of proliferation indicate that the drop in proliferation at 1 1/2 hours post exercise was transient. T-helper cell numbers changed very little. NK cells (0.49 x 10^9/L) significantly (p=0.001) but transiently increased at the post exercise period, when compared to exercise baseline (0.26 x10^9/L) or to baseline resting (0.21 x10^9/L). T-suppressor cell percentage also transiently increased (p=0.002) significantly immediately post exercise (33.2%) from 28.6% at baseline. Total leukocytes and lymphocytes increased (27% increase,p=0.001; 18% increase, p=0.01, respectively) in post exercise measures (compared to baseline). Both measures returned to near or below baseline level post 24 hours. Plasma cortisol and epinephrine levels

were primarily unchanged. There was a significant (p=0.01) increase (89%) in norepinephrine levels immediate post exercise compared to baseline level. A meal was ingested shortly after the venipuncture occurring 1 1/2 hours post exercise. The same major investigators (Nehlsen-Cannarella, Nieman, Balk-Lamberton et al, 1991) addressed many of the same immune functions in response to a moderate exercise walking program of five, 45-minute sessions per week for 15 weeks. Thirty-six sedentary, mildly obese women were examined at weeks 0, 6, and 15. Serum immunoglobulins IgA, IgG, and IgM increased 20% for the exercise group, but there was no significant difference between the control and exercise group at any point. Lymphocyte number (2.13, 2.24 x 10^9/L) and T-cells (1.68, 1.71 x 10^9/L) at both weeks 6 and 15 decreased significantly (p =0.05) with the exercise group compared to their baseline values (2.40, 1.87 x 10^9/L respectively). There was a slight but non-significant increase in the total leukocyte number. Mean percent lymphocytes significantly decreased (p=0.05) at weeks 6 (32.9%) and 15 (34.7%) compared to baseline (39.7%). No significant effect was observed in lymphocyte blastogenesis for the exercise group. Percent body fat and weight did not significantly change, but there was a significant decrease (p=0.05) in their submaximal heart rate (baseline, 162 b.p.m.; week 6, 152 b.p.m.; and week 15, 146 b.p.m.).

STRESS

The human body responds to stress in a variety of ways. Of principal interest is the effect of increased cortisol levels on different immune components. Increased cortisol levels and PMN leukocytes were found by Moorthy and Zimmerman (1978) in endurance runners. However, lymphocytes did not change. Interleukin production is in part regulated by corticosteroids (Watson, 1989). Questions remain regarding how exercise stress affects other components of the immune system.

Emotional state can be one of many factors affecting immune function (Kiecolt-Glaser, & Glaser, 1988). Irwin (1987) showed that there is an interrelationship between psychological stress, altered brain functions, and their combined effect on the immune system via reduced natural killer cell activity. Women with high levels of depression had significantly lower ($p=0.001$) natural killer cell activity than women with less depression.

SUMMARY

An intact immune system is crucial for maintaining a disease free state. The maintenance of a healthy immunosurveillance system depends upon many factors affecting the human body. Some factors such as age, gender, and other inherited traits cannot be altered. Cardiovascular fitness, proper weight control, stress management, and attention to specific nutrients are important when evaluating the maintenance of health via a competent immune system.

An overview of the literature regarding research for each component of lifestyle management illustrates the complexity of designing a human study which isolates only one variable's modulating effect on the immune system. There are very few studies involving these lifestyle factors, especially the relationship between exercise and immunity. Clearly, more studies are needed which examine the relationship of lifestyle management components and immunity.

CHAPTER III

METHODOLOGY

Subjects

Participation in the Reshape program was solicited through the use of public service announcements, newspaper articles, personal recommendations and referrals from the medical community. Individuals who registered for the Spring 1990 Reshape program were recruited for this research project. An informed consent form (Appendix A) approved by the department Human Subject's Review Committee was signed by each participant after disclosure of potential benefits and risks of the program. All subjects completed the medical history questionnaire (Appendix B). Individuals over the age of 35 or who had a medical history of heart disease, diabetes or hypertension regardless of age were required to have a physician's clearance (Appendix C). Participants were screened to be free of any acute or chronic infection or inflammatory disease. No subject was currently taking any medications known to affect immune status (Appendix D). Forty-eight subjects began the Reshape program. Eleven additional subjects were recruited through referrals to serve as control subjects.

The Reshape Program

The 12 week intervention program (Reshape) stresses lifestyle management. Participants were grouped according to individual fitness levels. An exercise therapist was assigned to work with each group. Participants met three times a week for exercise sessions. Each session consisted of a five to ten minute warm-up and cool-down intervened with 20-60 minutes of walking or running at a heart rate equal to 60-75% of their maximum value. All participants learned to monitor their exercise

intensity level. The initial 20 minute exercise period increased weekly by five minutes to a maximun of one hour. All participants met once a week for a one and one-half hour workshop which addressed a particular sub-component of lifestyle management, e.g. risk factor management. Prior to the workshop, a low fat, low sugar, nutrient dense meal was served to everyone. Seminar topics encouraged behavior modification and the development of wellness through nutritional awareness, stress management techniques, and physical activity. The weight reduction prescription of the Reshape program is based on the premise that subjects will reduce their energy intake by 300 kilocalories per day each week (a 2100 kcal per week deficit) and concommitantly increase their energy expenditure 300 kilocalories per day for five days each week (a 1500 kcal per week deficit). By following this pattern, participants would theoretically achieve a 3600 kilocalorie deficit weekly.

Dietary Analysis

All subjects were asked to complete a four-day food record during weeks 0 and 12. Each participant was given verbal and written instructions for completing the records (Bazzarre and Yuhas, 1983). Food records were chosen as the dietary intake instrument due to its established reliability and validity (Bazzarre and Meyers, 1979). Food records were analyzed using the Food Processor II™, computer software package (ESHA, Salem, OR, 1990). Values for total kilocalories; grams and percent kilocalories carbohydrate, protein, and fat; fiber; beta-carotene, vitamins A, C, and E; and; iron, zinc, and copper were averaged over each four day period and used as an average daily intake for statistical analysis.

Anthropometric Measurements: Indices of Body Fat

Weight to the nearest tenth of a kilogram was measured weekly, from week 0 to week 12 for each subject. Subjects were weighed without shoes or any outer garments using the Detecto™ beam balance scale.

Height was measured to the nearest tenth of a centimeter at week 0 using the attached stadiometer on the beam and balance scale.

Body mass index (BMI) was calculated using each person's weight in kilograms divided by their height in meters^2. Skinfold measurements (biceps, triceps, suprailiac, and subscapular) to the nearest 0.5 millimeter were taken at week 0 and week 12 on the right side of the body using the Lange™ Adipometer Skinfold Caliper. Percent body fat was estimated using the sum of four skinfold measurements in the conversion table by Durnin and Womersley (1974) (Appendix E).

Waist and hip circumferences were measured to the nearest tenth of a centimeter using a non-stretch measuring tape. Waist circumference was measured at a point one centimeter below the umbilicus. Hip circumference at the largest circumference below the waist. Measurements were taken at weeks 0 and 12. Waist to hip ratio (WHR) was used as an indicator of body fat distribution (Van Gaal, Vansant & De Leeuw, 1989).

Biochemical Analysis

Blood Samples. Blood was drawn by a trained phlebotomist from the antecubital vein of each subject and collected in Vacutainers™ preserved with EDTA. Trace mineral free Vacutainers ™ were used for collecting serum for zinc and copper analyses. Duplicate hematocrits were measured immediately according to the method of Strumia, Sample, and Hart (1954). An average value for the two readings for each subject was used for statistical analysis.

The remaining whole blood was centrifuged for 15 minutes at 3000 rpm, 10 degrees Centigrade. The sera was drawn off and labeled; 1.5 milliliter aliquots were immediately stepwise frozen from 0 degrees Centigrade to -70 degrees centigrade and, stored at the latter temperature until assayed.

Immunoglobulins. Quantitation of IgA, IgG, and IgM from blood serum at weeks 0 and 12 was done using NOR-Partigen radial

immunodiffusion plates from Behring Diagnostics, Somerville, New Jersey; based on the method of Mancini, Carbonara, and Heremans (1965). The NOR-Partigen Standard Set I (Behring Diagnostics, Somerville, New Jersey) was used to plate standards for construction of a reference curve for quantificaton of immunoglobulin concentrations. A detailed procedure for the immunoglobulin radial immunodiffusion (RID) assay is listed in Appendix F. Two microliters of each subject's serum were tested in duplicate for each of the three immunoglobulins by innoculation of labeled wells for plates for each immunoglobulin type. Each plate contained a uniform concentration of monospecific antibody (antisera) incorporated into a gel matrix. Plates were allowed to stand at room temperature in a horizontal position. Each assay plate included high and low controls. All plates were read at 48 hour endpoints, with an additional reading at 72 hours for IgM. The protein sera (antigen) diffused radially, producing a precipitin ring as it complexes with the excess antibody contained in the gel matrix. The diameter of each precipitin ring was measured to the nearest 0.1 millimeter using a TG Calibrating Viewer distributed by Kallestad Laboratories, Inc., Chaska, Ohio. Each measure (diameter) was squared and plotted on the Y-axis against the standard reference curve and read along the X-axis as its concentration. Since the plates were read at endpoint, the reference curve is linear and extrapolations were possible as defined by the upper and lower limits of the assay range listed on the plates. A representative value of the appropriate immunoglobulin (IgA, IgG, IgM) for each person was determined by averaging the two concentrations.

Exercise: Cardiovascular Fitness

Participant fitness levels were evaluated at weeks 0 and 12 by completing a one mile walk around a paved, premeasured track (Rockport Walking Institute [RWI], 1989). Subjects were instructed to walk at a brisk, maximum pace and their times were measured to the nearest

hundreth of a minute. Immediately following completion of the mile walk, a heart rate measure was taken for ten seconds. Each person's fitness level was rated based on their age, gender, and walking time.

Stress Measurements

Three different instruments were used to measure stress levels at weeks 0 and 12. A shortened form of the Schedule of Recent Events Inventory created by Holmes and Rahe, (1967) (Appendix G) was designed to rate an individual's general long-term life stress. The Current Self-Appraisal Questionnaire developed by Bazzarre (1985) (Appendix G) was designed to evaluate a person's general well being on the day of test administration. The third appraisal instrument, State-Trait Anxiety Inventory (state anxiety: STAI), was used to measure anxiety at the given time of completion. (Spielberger, Gorsuch, & Lushene, 1970) (Appendix G).

Statistical Analyses

Statistical analyses were performed with the data collected at weeks 0 and 12 for the subjects as a group and by gender using SAS (Statistical Analysis System [SAS], 1991). The dependent variables IgA, IgG, and IgM were addressed as influenced by the following independent variables: selected dietary nutrients, measures of body fat, stress, and fitness. Selected dietary nutrients included: total kilocalories; grams of carbohydrate, protein, fat, and fiber; percent of total kilocalories carbohydrate, protein; vitamins carotene, A, C, and E and minerals; iron, zinc, and copper. Measures of body fat included weight in kilograms, body mass index, and percent body fat based on the sum of four skinfold measures. Stress levels were determined by the Schedule of Recent Events, The Current Self-Appraisal Questionnaire, and the Personal Stress Inventory. Fitness levels were determined by the one mile walk time and exercise heart rate.

Basic descriptive statistics (means, ranges, standard error of means) were calculated using procedure univariate on all variables for weeks 0 and 12. Changes during the program were defined as week 0 minus week 12. Paired-differences t-tests were conducted to determine significant differences between week 0 and week 12. Significance was established at the $p \leq 0.05$ confidence level. Pearson correlation coefficient matrices were computed between the dependent and independent variables to identify important relationships for the regression models. All independent variables were retained that met the significance level of $p \leq .15$. ANOVAs (multiple regression) were conducted using each dependent variable (pre [week 0], post [week12]) and the appropriate independent variables identified via previous correlations, but using only those with correlations meeting a significance criteria of $p \leq 0.05$. ANOVAs were then conducted on the dependent change variables and the previous significant independent change variables to determine their relative contribution in explaining the model's variability. The type III sum of squares was also examined to determine if any of the independent variables, could significantly explain some of the model variability after controlling for variability contributed by all the other independent change variables in the model.

CHAPTER IV

RESULTS

The results of this research are summarized in Tables 1 through 16 and Appendices J through H. The results for the cross-sectional study are presented first, followed by the results for the longitudinal study. In the latter section the results for the overall impact of the lifestyle management intervention are presented first. Results are reported in the same order as the hypotheses. Mean descriptive data and analyses for week 12 are located in Appendix H.

STATISTICAL ANALYSES

Data in tabular form were reported as appropriate for the hypotheses of this dissertation research. Means, standard errors of the mean, and ranges were calculated for each variable (independent and dependent, pre- [week 0] and post [week 12] intervention). Paired-differences *t*-tests were used to determine if differences between week 0 and week 12 values were significantly different. Pearson correlation coefficients were computed between the dependent (IgA, IgG, IgM) variables at week 0 and each independent variable at week 0 for the following lifestyle management components: selected nutrient intakes (total kilocalories; grams and percent kilocalories carbonydrate, protein, and fat; fiber; beta-carotene, vitamins A, C, and E; iron, zinc, and copper); measures of obesity (body weight, BMI, and percent body fat;) cardiovascular fitness (exercise heart rate and mile walk time;) and stress (Schedule of Recent Events Inventory, Current Self-Appraisal Questionnaire, and State-Trait Anxiety Inventory). Significance levels are reported in the text only at $p \leq 0.05$ level.

Correlations with a p-value of 0.15 or less were retained for use

with analysis of variance (ANOVA). Separate ANOVAs were computed using week 0 data and change data (week 0 minus week 12). ANOVAs were used to determine significant variability in the model using only the group data. Data analyses for the dietary variables were conducted for males and females combined because of the small sample size for males (i.e., 12 males at week 0). Use of the principal component analysis was unsuccessful (due to the small number of subjects) when attempting to collapse the dietary variables to a single nutrient variable in the ANOVA model. Results from ANOVAs which met the model significance criterion were included in Tables 15 and 16. Each ANOVA table includes the R^2, or total amount of variability explained by the model along with the type III sum of squares, the associated F value and the significance level for each variable.

Subjects: Week 0 Descriptives

Forty-seven subjects were recruited for the study, with 11 additional people serving as controls. Descriptive data (age, height, weight) for the Reshape participants at week 0 are presented in Table 1. The control group was dropped from the study due to the small number of subjects and because of incomplete data. The following tables contain descriptive information for the total group, and for each gender for week 0 as follows: Table 2 - anthropometric data (BMI, body fat, waist circumference, hip circumference, waist:hip ratio; Table 3 - select nutrient intake for kilocalories and percent of kilocalories for carbohydrates, protein and grams of fat, fiber, carbohydrates, protein, fat; Table 4 - intakes for vitamin A, beta-carotene, vitamin E, vitamin C, iron, zinc, and copper; Table 5 - biochemical measures for IgA, IgG, IgM, hematocrit, and vitamin C; and Table 6 - stress and exercise measures for Life events Inventory, Current Self Appraisal, State-Trait Anxiety, exercise heart rate, and mile walk time.

Table 1

Descriptive Information (Means + SEM) of Reshape Subjects at Week 0

Variable	Total (n=47)	Females (n=31)	Males (n=16)
Age (yrs) (Range)	46.4 ± 1.8 (17-89)	46.0 ± 2.6 (17-89)	46.9 ± 1.5 (38-62)
Height (in) (Range)	66.4 ± 0.6 (59-76)	64.1 ± 0.5 (59-69)	70.7 ± 0.7 (67-76)
Weight (kg) (Range)	82.1 ± 3.1 (51.3-153.7)	72.4 ± 2.4 (51.3-108.7)	101 ± 5.2 (69.8-153.7)

Table 2

Anthropometric Data (Means + SEM) of Reshape Subjects at Week 0

Variable	Total (n=47)	Females (n=31)	Males (n=16)
BMI (wt/ht^2)	28.6 ± 0.8	27.3 ± 0.9	31.3 ± 1.6
(Range)	(18.3-45.3)	(18.3-39.9)	(24.1-45.3)
Body Fat (%)	33.8 ± 0.8	35.3 ± 0.7	30.8 ± 1.8
(Range)	(20.8-45.7)	(26.3-43.8)	(20.8-45.7)
Waist (cm) Circumference	102.7 ± 2.4	97.0 ± 2.4	113.2 ± 4.4
(Range)	(69.9-153.7)	(69.9-130.8)	(88.9-153.7)
Hip (cm) Circumference	108.8 ± 2.0	108.6 ± 2.2	109.1 ± 4.2
(Range)	(88.9-148.6)	(88.9-134.0)	(88.9-148.6)
Waist/Hip Ratio	0.95 ± .02	0.89 ± .01	1.05 ± .04
(Range)	((.79-1.60)	(.79-1.01)	(.82-1.60)

Table 3

Select Nutrient Intakes (Means + SEM) of Reshape Subjects at Week 0

Nutrient	Total (n=35)	Females (n=23)	Males (n=12)
Kilocalories	1926 ± 101	1734 ± 104	2311 ± 175
(Range)	(426-3411)	(426-3059)	(1475-3411)
Carbohydrates (g)	228.8 ± 13.0	202.8 ± 12.0	280.8 ± 24.9
(Range)	(51-511)	(51-324)	(192-511)
Protein (g)	76.3 ± 4.0	72.3 ± 4.6	84.3 ± 7.3
(Range)	(15.2-124)	(15.2-124)	(42.5-120)
Fat (g)	79.8 ± 5.4	71.7 ± 5.6	95.8 ± 10.7
(Range)	(19.7-166)	(19.7-142)	(49.3-166)
Fiber (g)	16.5 ± 1.1	15.3 ± 1.3	18.9 ± 1.7
(Range)	(4.9-35.9)	(4.9-35.9)	(7.7-27.6)
Percent of Kilocalories:			
Carbohydrates	47	47	49
(Range)	(35-69)	(35-69)	(41-68)
Protein	16	17	15
(Range)	(10-21)	(11-21)	(10-20)
Fat	36	36	37
(Range)	(20-49)	(20-49)	(21-46)

Table 4

Select Vitamin and Mineral Intakes (Means + SEM) of Reshape Subjects at Week 0

Variable	Total (n=36)	Females (n=24)	Males (n=12)
Vitamins:			
Vitamin A (RE)	924.3 ± 82.3	870.6 ± 98.6	1031.5 ± 149.8
(Range)	(208-2110)	(208-2110)	(303-2011)
RDA		800	1000
Beta-Carotene (RE)	428.9 ± 53.8	411.4 ± 62.2	463.8 ± 105.1
(Range)	(49-1379)	(49-1092)	(82-1379)
Vitamin E (mg)	12.2 ± 0.9	11.5 ± 0.9	13.8 ± 1.9
(Range)	(2.2-27.7)	(4.3-24.1)	(2.2-27.7)
RDA		8	10
Vitamin C (mg)	107.1 ± 13.5	101.0 ± 18.5	119.2 ± 16.6
(Range)	(21.2-389)	(21.2-389)	(46-235)
RDA		60	60
Minerals:			
Iron (mg)	12.3 ± 0.6	10.9 ± 0.6	15.1 ± 1.1
(Range)	(2.6-20.2)	(2.6-15.9)	(7.7-20.2)
RDA		15	10
Zinc (mg)	9.9 ± 0.6	9.0 ± 0.7	11.7 ± 0.9
(Range)	(1.9-18.1	(1.9-18.1)	(6.5-17.6)
RDA		12	15
Copper (mg)	1.3 ± 0.1	1.1 ± 0.1	1.6 ± 0.1
(Range)	(.3-2.2)	(.3-2.1)	(.7-2.2)
Reference		1.5-3.0	1.5-3.0

Note: Beta-Carotene requirements are 2x that needed meeting Vitamin requirements.

Table 5

Biochemical Measures (Means + SEM) of Reshape Subjects at Week 0

Variable	Total (n=43)	Females (n=28)	Males (n=15)
IgA (mg/dl)	189.9 ± 15.5	191.5 ± 21.3	187.1 ± 20.9
(Range)	(63-543)	(63-543)	(93-343)
Reference		90-450	90-450
IgG (mg/dl)	980.1 ± 45.4	908.1 ± 50.8	1114.7 ± 80.6
(Range)	(418-1630)	(418-1560)	(700-1630)
Reference		800-1800	800-1800
IgM (mg/dl)	153.6 ± 17.1	197.1 ± 21.1	72.2 ± 13.6
(Range)	(18-473)	(56-473)	(18-192)
Reference		80-322	60-250
Hematocrit (% rbc)	45.2 ± 0.6	42.7 ± 0.4	50.0 ± 0.7
(Range)	(39-56)	(39-49)	(45-56)
Reference		37-47%	40-54%
Vitamin C (umol/L)	0.95 ± 0.1	0.92 ± 0.1	0.99 ± 0.1
(Range)	(.3-1.7)	(.4-1.7)	(.3-1.6)
Reference		0.6-1.6	0.6-1.6

Table 6

Stress and Exercise Values (Means + SEM) of Reshape Subjects at Week 0

Variable	Total (n)	Female (n)	Male (n)
Stress:			
Life Events Inventory (Range)	206 ± 30 (46) (26-996)	231 ± 42 (30) (38-996)	159 ± 29 (16) (26-522)
Current Self-Appraisal (Range)	33.6 ± 0.8 (45) (22-45)	33.6 ± 1.2 (29) (22-45)	33.7 ± 0.9 (16) (27-41)
State-Trait Inventory (Range)	34.6 ± 1.7 (31) (20-56)	35.7 ± 2.2 (20) (20-56)	32.5 ± 2.7 (11) (20-49)
Exercise:			
Exercise Heartrate (beats/10 seconds) (Range)	23 ± 1 (44) (15-29)	24 ± 1 (29) (15-29)	22 ± 1 (15) (17-28)
Mile Walk Time (minutes) (Range)	15.6 ± 0.3 (45) (11.5-20)	16.1 ± 0.3 (29) (13-20)	14.7 ± 0.4 (16) (11.5-17)

Thirty-six of the forty-two people completing the Reshape program were evaluated at week 12. Appendix H contains descriptive data andcorrelations for week 12 in the same format as described for week 0. Biochemical analyses for vitamin C were not conducted on week 12 samples due to inability to perform the analyses immediately post-draw.

HYPOTHESES

CROSS-SECTIONAL STUDY

Lifestyle Management Factors and Immunoglobulins

What is the relationship between the independent variables of this study and immune function?

To maximize the greater statistical power of a larger number of participants, emphasis was directed toward dependent and independent variable analyses at week 0. Only the data from week 0 were used to test the following hypotheses:

Dietary

H:1 There will be an association between immunoglobulins IgA, IgG, IgM and diet (kilocalories; carbohydrate; protein; percent kilocalories, carbohydrate, protein, fat; vitamins, A, C, E, and beta-carotene; and iron, zinc, and copper).

Group: There was a significant negative relationship between IgM and kilocalories ($r=-0.32$; $p \leq 0.05$), grams of protein ($r=-0.33$; $p \leq 0.05$), grams of fat ($r=-0.32$; $p \leq 0.05$), iron ($r=-0.33$;$p \leq 0.05$), and copper ($r=-0.34$; $p \leq 0.05$)(Table 7). The hypothesis was accepted for the group for a significant association between IgM and kilocalories, grams of protein, grams of fat, iron, and copper. The hypothesis was rejected for all other group nutrient-immunoglobulin relationships.

Table 7

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Selected Variables for All Subjects at Week 0 (P-vlaue < 0.15)

Variable	IgA	IgG	IgM
Anthropometric (n=43):			
Age	-	-0.27	-0.23
Weight	0.28	0.39*	-0.35
Body Mass Index	0.24	0.29*	-
Waist Circumference	-	-	-0.22
Hip Circumference	0.26	-	-
Waist : Hip Ratio	-	-	-0.28
Dietary (n=33):			
Kilocalories	-	-	-0.32*
Protein (g)	-	-	-0.33*
Fat (g)	-	-	-0.32*
Iron	-	-	-0.33*
Zinc	-	-	-0.30
Copper	-	-	-0.34*

$p \leq 0.05$

Females: There was a significant relationship between IgM and vitamin E ($r=-0.48$; $p \leq 0.01$)(Table 8). The hypothesis was accepted for a significant relationship between IgM and vitamin E, and rejected for the other nutrient-immunoglobulin relationships.

Males: There was a significant relationship between IgA and vitamin A ($r=0.63$; $p \leq 0.05$), and vitamin C ($r=0.71$; $p \leq 0.05$). No significant nutrient-IgG relationship was found. Vitamin E was the only nutrient significantly related to IgM ($r=0.60$; $p \leq 0.05$), (Table 9) among males. The hypothesis was accepted for a significant relationship

between IgA and vitamins A and C, and between IgM and vitamin E. The hypothesis was rejected for all other nutrient-immunoglobulin relationships.

Table 8

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Selected Variables for Female Subjects at Week 0 P-value< 0.15

Variable	IgA	IgG	IgM
Anthropometric (n=28):			
Age	-	-0.38*	-0.30
Weight	0.38	0.48*	-
Body Mass Index	-	0.40	-
Percent Body Fat	-	-	-0.36*
Hip	0.30	0.31	-
Dietary (n=22):			
Protein (g)	-	-0.35	-0.35
Fat (g)	-	-	-0.33
% Kcal Fat	-	-	-0.33
% Kcal Carbohydrates	-	-	-0.34
Vitamin A	-	-	-0.32
Vitamin E	-	-	-0.48**
Copper	-	-	-0.31

* $p \leq 0.05$ level, ** $p \leq 0.01$ level

Table 9

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Select Variables for Male Subjects at Week 0 (P-value < 0.15)

Variable	IgA	IgG	IgM
Anthropometric: (n=15)			
Weight	0.40	-	-0.47
Hip	-	-	-0.45
Dietary: (n=11)			
Protein (g)	0.51	-	-
Vitamin A	0.63*	-	-
Vitamin C	0.71	-	-
Vitamin E	-	-	0.60*

* $p \leq 0.05$

Obesity

H:2 There will be an association between measures of obesity and immunoglobulins IgA, IgG, and IgM.

Group: There was a significant relationship between the mean body weight ($r=0.39$; $p \leq 0.05$) and IgG. IgG was also significantly related to BMI ($r=0.29$; $p \leq 0.05$) (Table 7). The hypothesis was accepted for mean body weight, BMI and IgG only.

Females: There was a significant relationship between the mean body weight ($r=0.48$; $p \leq 0.05$) and IgG (Table 8). IgG was also significantly related to BMI ($r=0.40$; $p \leq 0.05$)(Table 8). Percent body fat was significantly correlated with IgM ($r=-0.36$; $p \leq 0.05$)(Table 8). The hypothesis was accepted for females for mean body weight, BMI, and IgG; for percent body fat and IgM only.

Males: There were no significant correlations between any of the measures of body fat and the immunoglobulins. The hypothesis was rejected for males.

Cardiovascular Fitness

H:3 There will be an association between measures of fitness and immunoglobulins IgA, IgG, and IgM.

Group: There was a significant relationship between the mean exercise heart rate ($r=0.35$; $p \leq 0.05$) and IgM. IgM was also significantly correlated with the mean mile walk time ($r=0.30$; $p \leq 0.05$) (Table 10). The hypothesis was accepted for the relationship with IgM only.

Females: There were no significant correlations between any of the measures of cardiovascular fitness and IgA, IgG, IgM. Thus, the hypothesis was rejected for females.

Table 10

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Exercise, Stress, and Biochemical Variables for All Subjects at Week 0 P-value < 0.15

Variable	IgA	IgG	IgM
Exercise (n=43):			
Exercise Heartrate	-	-0.22	0.35*
Mile Walk Time	-	-	0.30*
Stress (n=41):			
Current Self-Appraisal	-0.27	-	-
Biochemical (n=43):			
IgG	-	-	0.46
Hematocrit	-	0.25	-0.41*

* $p \leq 0.05$

Males: There were no significant correlations between any of the measures of cardiovascular fitness and IgA, IgG, IgM. Thus, the hypothesis was rejected for males.

Measures of Stress

H:4 There will be an association between measures of stress and immunoglobulins IgA, IgG, IgM.

Group: There were no significant correlations between any of the measures of stress and IgA, IgG, IgM. The hypotheses were rejected for the group.

Females: There was a significant relationship between the Current Self-Appraisal mean score and IgA ($r=-0.38$; $p \leq 0.05$)(Table 11). The

hypothesis was accepted for a relationship between the Current Self-Appraisal mean score and IgA.

Males: There were no significant correlations between any of the measures of stress and IgA, IgG, IgM. The hypotheses were rejected.

Table 11

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Exercise, Stress, and Biochemical Variables for Female Subjects at Week 0 P-value < 0.15

Variable	IgA	IgG	IgM
Exercise (n=28):			
Exercise Heartrate	-	-	0.31
Stress (n=28):			
Current Self-Appraisal	-0.38*	-	-
Biochemical (n=28):			
IgG	-	-	0.46**

* $p \leq 0.05$ level, ** $p \leq 0.01$ level

H:5 A significant amount of the variability in the immunoglobulin levels will be explained by the selected components of lifestyle management.

As addressed earlier, the small number of individuals (n=8) returning food records prohibited inclusion/analysis using ANOVA for week 12 and change variables for dietary nutrient intake.

Week 0 IgA Model:

Selected lifestyle management components exhibiting a priori significant correlations (weight, mile walk time, dietary fat and protein) did not significantly contribute to explaining the IgA model variability. The hypothesis was rejected for the IgA variability model.

Week 0 IgG Model:

The model with age, weight, mile walk time, dietary protein, and dietary fat significantly contributed to the IgG model's variability (R^2=0.37; $p \leq 0.0223$). Weight ($p \geq 0.0028$) and mile walk times ($p \leq 0.0509$) individually significantly contributed to the IgG model variability after adjusting for all other variables in the model (Table 12).

Table 12

ANOVA (Multiple Regression) for IgG and Select Independent Variables at Week 0 (n=33)

Variable	Type III SS	R^2	DF	F Value	P Value
Model		.25	2	5.04	.0130
	Age			0.48	.4957
	Weight			8.53	.0066
Model		.32	3	4.64	.0091
	Age			0.04	.8491
	Weight			9.41	.0046
	Mile Walk Time			3.12	.0877
Model		.37	5	3.17	.0223
	Age			0.32	.5753
	Weight			10.82	.0028
	Mile Walk Time			4.18	.0509
	Dietary Protein			0.92	.3448
	Dietary Fat			1.89	.1809

The hypothesis was accepted that the lifestyle management variables weight, mile walk times, dietary protein and fat significantly contributed to the IgG model. The hypothesis was accepted that body weight significantly accounted for variability in the IgG model after adjusting for the combinations of lifestyle management components (mile walk times, dietary protein and fat).

Week 0 IgM: The model with age, weight, mile walk time, dietary protein, and dietary fat significantly contributed to the IgM model's variability (R^2=0.37; $p \leq 0.0238$). Individually, age ($p \leq 0.0324$), and mile walk time ($p \leq 0.0217$) individually significantly contributed to the IgM model's variability after adjusting for all other variables (age, weight, mile walk time, dietary protein and fat)(Table 13). Age was a consistently significant variable for IgM. The hypothesis was accepted that weight significantly accounts for adjusted variability in the IgM model which included age, weight, and mile walk time only. The hypothesis was accepted (i.e. that the lifestyle management variables weight, mile walk times, dietary protein and fat when combined with age significantly contributed to the IgM model).

Table 13

ANOVA (Multiple Regression) for IgM and Select Independent Variables at Week 0 (n=33)

Variable	Type III SS	R^2	DF	F Value	P Value
Model		.15	2	2.67	.0859
	Age			-	-
	Weight			-	-
Model		.34	3	4.96	.0067
	Age			6.35	.0175
	Weight			4.93	.0343
	Mile Walk Time			8.25	.0075
Model		.37	5	3.12	.0238
	Age			5.09	.0324
	Weight			2.63	.1164
	Mile Walk Time			5.94	.0217
	Dietary Protein			0.11	.7483
	Dietary Fat			0.11	.7390

LONGITUDINAL STUDY

Impact of Reshape Program

The difference between week 0 and week 12 variables were calculated by subtracting week 12 from week 0. In other words, a negative mean difference value indicates that the value at week 12 was greater than at week 0.

H:6 Reshape participants will weigh less at week 12 than at week 0.

The mean weight loss by the Reshape participants as a group (3.7 $\pm$ 0.7 kg); for females (2.2 kg $\pm$ 0.6), and males (5.6 kg $\pm$ 1.5) was significant ($p \leq 0.001$)(Table 14). The hypotheses were accepted for the group, females, and males.

H:7 Reshape participants will have less body fat at week 12 than week 0.

The mean percent body fat loss for the Reshape participants as a group (3.5 $\pm$ 0.5), females (2.2 $\pm$ 0.4), and males (5.1 $\pm$ 0.9) significantly ($p<0.001$) decreased by week 12 (Table 14). Mean difference BMI values for the group (1.2 $\pm$ 0.2), females (0.86 $\pm$ 0.2), and males (1.7 $\pm$ 0.4) decreased ($p \leq 0.001$) significantly by week 12 (Table 14). The hypotheses were accepted for the group, females, and males.

H:8 Stress measures of Reshape participants will improve from week 0 to week 12.

The Life Events Inventory was administered at week 0 as a one time evaluation. The mean difference of the group (-2.3 $\pm$ 0.8; $p\leq 0.01$) and for males (-3.9 $\pm$ 0.8; $p\leq 0.01$)(Table 15) for the Current Self-Appraisal was significantly improved at week 12. The mean difference of the group (3.1 $\pm$ 1.4; $p\leq 0.05$) for State-Trait Anxiety Inventory was significantly

improved at week 12 (Table 15). This hypothesis was accepted for the Current Self-Appraisal for the group and males. For the State-Trait Anxiety Inventory, the hypothesis was accepted for the group only.

H:9 Measures of cardiovascular fitness will improve from week 0 to week 12.

Mean mile walk times decreased significantly (1.2 $\pm$ 0.2 minutes; $p \leq 0.001$) for the group, for females (1.2 $\pm$ 0.2 minutes; $p=<0.001$), and for males (1.3 $\pm$ 0.2; $p \leq 0.01$) (Table 15). The hypotheses were accepted for the group, for females, and males for the mile walk time. The hypothesis for the mean difference in exercise heart rate was rejected for all groups.

Table 14

Mean + SEM Differences (Week 0 minus Week 12) of Select Variables of Reshape Subjects

Variable	Total (n=35)	Females (n=20)	Males (n=15)
Anthropometric:			
Weight Loss (kg) (Range)	3.7 ± 0.7*** (-3.1-19.0)	2.2 ± 0.6*** (-3.1-8.8)	5.6 ± 1.5*** (-.1-6.9)
BMI Change (wt/ht^2) (Range)	1.2 ± 0.2*** (-1.1-5.6)	0.86 ± 0.2*** (-1.1-3.3)	1.7 ± 0.4*** (-.04-5.6)
Body Fat Loss (%) (Range)	3.5 ± 0.5*** (.2-11.3)	2.2 ± 0.4*** (.2-6.1)	5.1 ± 0.9*** (.8-11.3)
Waist Reduction (cm) (Range)	6.0 ± 1.8** (-5.7-59.1)	5.4 ± 1.2** (-5.7-14.6)	9.1 ± 3.9* (-3.2-59.1)
Hip Reduction (cm) (Range)	2.4 ± 0.8** (-6.4-14.6)	2.1 ± 0.9* (-6.4-10.2)	2.8 ± 1.5 (-5.1-14.6)
Biochemical	**n=34**	**n=20**	**n=14**
IgA Change (Range)	9.3 ± 9.7 (-129-133)	6.1 ± 13.0 (-129-125)	13.9 ± 14.3 (-74-133)
IgG Change (Range)	24.3 ± 37.7 (-379-540)	-56.6 ± 36.6 (379-288)	139.8 ± 65.1* (-287-540)
IgM Change (Range)	-9.3 ± 8.6 (-110-135)	-3.6 ± 11.5 (-98-135)	-17.5 ± 13.0 (-110-78)
Hematocrit Change (Range)	0.2 ± 0.4 (-4-5.0)	-0.15 ± 0.7 (-4-4.0)	0.67 ± 0.6 (-3-5.0)

* $p \leq 0.05$ level; ** $p \leq 0.01$ level; *** $p \leq 0.001$ level

Table 15

Mean + SEM Differences (Week 0 minus Week 12 of Stress, Exercise, and Dietary Values of reshape Subjects

Variable	Total (n)	Females (n)	Males (n)
Exercise			
Exer. Heartrate (Range)	-2.0 ± 1.0 (22) (-12-6.0)	-1.3 ± 1.2 (15) (-12-6.0)	-3.6 ± 1.7 (7) (-9-2.0)
Mile Walk Time (Range)	1.2 ± 0.2*** (28) (-.3-2.9)	1.2 ± 0.2*** (16) (-.3-2.9)	1.3 ± 0.2** (12) (.3-2.6)
Stress			
Current Self-Appraisal (Range)	-2.3 ± 0.8** (28) (-12-6.0)	-1.1 ± 1.2 (16) (-12-6.0)	-3.9 ± 0.8** (12) (-10-0.0)
State-Trait Anxiety (Range)	3.1 ± 1.4* (27) (-6-19.0)	3.1 ± 2.0 (16) (-6-19.0)	3.2 ± 12.9 (11) (-6-17.0)
Dietary (n=8)			
Fat (g) (Range)	24.3 ± 7.1** (-15-50.9)		
% Kilocalories Fat (Range)	6.5 ± 2.4* (-3-15)		
Beta-Carotene (RE) (Range)	-424 ± 138** (-424- -100)		

* $p \leq 0.05$ level; ** $p \leq 0.01$ level; *** $p \leq 0.001$ level

Dietary

Twenty-two percent of the food records (n=8) were completed and returned from the post population (n=36). Selected nutrient intakes were thus not included in analyses of the change variables (week 0 minus week 12). Data from both weeks 0 and 12 were used to test the following hypotheses:

H:10 Reshape participants will reduce their dietary intake of fat.

The average dietary intake of fat was significantly reduced (24.3± 7.1 grams; p=≤ 0.01) by week 12. Fat intake as a percent of total kilocalories was significantly reduced 6.5 ± 2.4; p≤ 0.05) (Table 15) by week 12. These hypotheses were accepted.

H:11 Reshape participants will increase their dietary intake of vitamins A, C, and E as well as beta-carotene.

The average dietary intake of vitamin A (change amount), C (change amount), and E (change amount) did not significantly increase by week 12. Average beta-carotene intake increased (-424 ± 138 RE; p≤ 0.01)(Table 15) significantly by week 12. The hypothesis was rejected for vitamins A, C, E, and accepted for beta-carotene.

H:12 Reshape participants will increase their dietary intake of iron, zinc, and copper.

The average dietary intake of iron, zinc, and copper did not significantly increase by week 12. The hypothesis for increasing their dietary intake of iron, zinc, and copper was rejected.

LONGITUDINAL STUDY CORRELATIONS

H:13 A reduction of dietary fat intake will be associated with changes in IgA, IgG, IgM.

Group: There was no significant correlation between the mean difference of dietary fat intake and any of the immunoglobulin mean differences. This hypothesis was rejected.

H:14 Changes in dietary intakes of vitamins A, C, and E and beta-carotene will be associated with changes in IgA, IgG, IgM.

Group: There was no significant correlation between the mean difference dietary intakes of vitamins A, C, E, beta-carotene and any of the immunoglobulin mean differences. These hypotheses were rejected.

H:15 Changes in dietary intakes of iron, zinc, and copper will be associated with changes in IgA, IgG, IgM.

Group: There was no significant correlation between the mean difference dietary intakes of iron, zinc, or copper and any of the immunoglobulin mean differences. These hypotheses were rejected.

Body fat

H:16 A reduction of body fat measures will be associated with changes in IgA, IgG, and IgM.

Group: There was a significant relationship between the hip circumference mean difference (-0.34; $p \leq 0.05$) (Table 16) and IgA mean difference. There was a significant relationship between the percent body fat mean difference (0.41; $p \leq 0.01$) (Table 16) and IgG mean difference. These hypotheses were accepted for the relationship between percent body fat mean difference and IgG mean difference. The hypothesis was accepted for the relationship between hip circumference mean difference and the IgA mean difference.

Table 16

Mean Differences: Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Select Variables for All Subjects P-Value < 0.15

Variable	IgA (n)	IgG (n)	IgM (n)
Anthropometric:			
Percent Body Fat	0.26 (32)	0.41** (32)	-
Hip Circumference	-0.34* (33)	-	-
Exercise:			
Exercise Heartrate	0.40 (17)	0.46 (17) ($p \leq 0.06$)	-
Mile Walk Time	-	-0.39 (22) ($p \leq 0.07$)	-
Stress:			
Current Self-Appraisal	0.50* (26)	-	0.31 (26)
Biochemical:			
IgA	-	0.46** (34)	0.57** (34)
Hematocrit	0.52***(33)	0.32 (33) ($p \leq 0.06$)	0.33* (33)

* $p \leq 0.05$ level; ** $p \leq 0.01$ level; *** $p \leq 0.001$ level

Cardiovascular Fitness

H:17 Changes in measures of cardiovascular fitness will be associated with changes in IgA, IgG, IgM.

Group: There was no significant correlation between the mean differences of measures of cardiovascular fitness and any of the immunoglobulin mean differences. These hypotheses were rejected.

Stress

H:18 Changes in measures of stress i.e., Recent Events Inventory, Current Self-Appraisal, and State-Trait Anxiety Inventory will be associated with changes in IgA, IgG, IgM.

Group: There was a significant relationship between the Current Self-Appraisal mean difference (0.50; $p \leq 0.05$) (Table 16) and IgA mean difference. The hypothesis was accepted for the relationship between the Current Self-Appraisal mean difference and the IgA mean difference.

H:19 Immunoglobulin levels of Reshape participants will change from week 0 to week 12.

There was a significant decrease ($p \leq 0.05$) in IgG (139.8 $\pm$ 65.1 mg/dl) for males (Table 14). The hypothesis was accepted only for IgG for males.

CHAPTER V

DISCUSSION

This discussion has been organized according to each hypothesis listed in the results. Comparisons of these data with results previously reported in the literature are addressed where applicable. A discussion of the limitations of this dissertation research and recommendations for future research concerns are also included.

What was the relationship between the independent variables of this study and immune function?

CROSS-SECTIONAL STUDY

Dietary

H:1 There will be an association between immunoglobulins IgA, IgG, IgM and diet (kilocalories; carbohydrate; protein; percent kilocalories, carbohydrate, protein, fat; vitamins, A, C, E, and beta-carotene; and iron, zinc, and copper.

IgM was significantly correlated with kilocalories (r=-0.32), protein (r=-0.32), fat (r=-0.32), iron (r=-0.33), and copper (r=-0.34); for vitamin E in (r=-0.48) women; and vitamin E (r=0.60) in males. IgA was positively correlated with vitamins A (r=0.63), and vitamin C (r=0.71) in males respectively.

Chandra (1991) citing other research reported on the gestational effects of individual nutrient deficiencies on IgM levels in rodents, noted that deficiencies of vitamin A, iron, zinc and vitamin B-6 were associated with decreased IgM levels. Thus, it appears that circulating

immunoglobulin levels may be affected by more than one nutrient. Furthermore, circulating levels of immunoglobulins may be so exquisitely controlled that increases or decreases in the intake of selected nutrients (high and low thresholds for nutrient intakes) may both decrease immunoglobulin concentrations under normal conditions (i.e., the absence of any provocative stimuli such as infection).

The subjects in this study were obviously not in danger of PCM. The issue of concern in today's lifestyle is compromised immune function associated with overnutrition (Chandra, 1981). Prolonged excess caloric intake eventually contributes to obesity, cardiovascular disease, hypertension diabetes, and presumably alterations in immune status as well. All of the significant correlations between IgM and the nutrients were negative (except vitamin E in males) suggesting a consistent effect of increased intakes of these nutrients on decreased IgM "synthesis". According to Chandra (1988), the extent and severity of deficient energy-protein intakes determines the extent of PCM's effect on both humoral and cell-mediated responses. Unfortunately, the variability in responses of studies on changes in IgG, IgA and IgM has been so extreme that it has been impossible to conclude whether PCM will increase, decrease or have no effect on immunoglobulins. Since iron and copper nutriture often change as a consequence of changes in protein intake (i.e., meat intake), it was not surprising that the negative association for iron paralleled the associations observed for protein and energy. Future studies of large numbers of subjects might help differentiate the extent to which this cluster of associations were independent of each other or whether they were possibly a reflection of meat (protein-energy) intake.

Iron and copper are important mineral constituents necessary for biochemical processes. Both excess iron (Akbar, Fitzgerald, De Susa, Giardina, Hilgartner & Grady, 1986 & Ward, 1987) and iron deficiency can alter immune function.

Dietary intakes of copper were relatively poor, especially for women. Marginal/deficient copper status has been associated with impaired immune function in some animal studies (Chandra, 1988); and the quaternary structure of immunoglobulins are partly dependent on copper. The significant negative association between IgM and copper compared to the other nutrients is of interest, because copper intakes were marginal whereas energy, protein and iron intakes appeared to be adequate. The effects of copper deficiency on altered immune function are apparently organ specific, and vary depending on the type of carbohydrate consumed (Babu & Failla, 1989); however, it is unclear if these effects are species specific (rats were used); and immunoglobulins were not measured in this research.

Vitamin E intake was positively associated with IgM levels in males. Vitamin E intakes were well above the RDA for males. These results are consistent with improved immune function and cell membrane integrity after 300 mg/day supplementation in vitamin E deficient hemodialysis patients (Taccone-Gallucci, Giardini & Ausiello, 1986).

Vitamin C was significantly associated with IgA ($r=0.71$) in this dissertation study. Anderson et al. (1980) did not find any changes in IgA, IgG, or IgM after supplementation with 1, 2, or 3 grams of vitamin C. The lack of any significant association between vitamin C supplementation and changes in immunoglobulin response may be due to the fact that the levels used in the supplement were too high above physiological levels to show any differences. Tissue vitamin C stores are usually achieved at levels of 100-150 mg per day (10% of the lowest dose used by Anderson et al). Thus, future studies should use lower doses as the basis for evaluating the effects of vitamin C supplementation on immunoglobulin responses; should have at least a control group; and should control for vitamin C status prior to the beginning of the study. No specific studies that parallel this dissertation study were found in the literature.

Obesity

H:2 There will be an association between measures of obesity and immunoglobulins IgA, IgG, and IgM.

IgG was positively correlated with body weight(r=0.39), and BMI (r=0.29) for the group and for females (body weight: r=0.48, BMI: r=0.40). However, IgM was negatively correlated with body fat (r=-0.36) for females. None of the correlations between the immunoglobulins at week 0 and any measure of body fat were significant among males. The lack of significance may be related to the small sample size. There was no apparent relationship between fat deposition (waist, hip or WHR) and any of the immunoglobulins.

Obese individuals have a higher incidence of wound infection (Rhoades, 1964; Cruse & Foord, 1973; Meares, 1975). The same tendency toward increased wound infection was observed for elderly patients as well; however, the criteria for defining obesity were not provided. Chandra and Kutty (1980) used a combination of factors (physical characteristics, mean sum of 3 skinfolds greater than 20 mm, and a weight for height index greater than the 95th percentile) to define selection criteria for 28 obese children. Normal IgA, IgG, and IgM values were reported for the group (20% overweight) of girls and boys ranging in age from 6-18 years when compared to the age matched control group. However, other cell-mediated immune functions were impaired in 38% of this group.

Wing et al. (1983) found IgA (22%), IgG (19%), and IgM (16%) levels increased significantly (p=0.01) after a 14-day controlled starvation diet of 15 obese subjects (mean weight: 117 $\pm$ 41 kg; mean height: 165 $\pm$ 9 cm; mean age: 37 $\pm$ 15 years). Although the method of weight-loss of this group (starvation) compared to the lifestyle management treatment was radically different, both groups lost weight. The Reshape group was older (46 years) while their BMI was lower (28.6)

than the group studied by Wing et al (42.9). Reshape participants lost an average of 3.7 ± 0.7 kg during 12 weeks compared to 9.4 ± 4.1 kg for the starvation group (80 kcal/day). The correlations between IgG, IgM measures and both indices of obesity for the subjects in this dissertation are in contrast to the findings of Wing et al. The differences in the results of these two studies may reflect differences in the rates of weight/fat losses. One might conjecture that the weight loss of 9.4 kg (about 20 pounds) reported by Wing et al may have been primarily a reflection of decreased lean body mass and body water compared to a loss of primarily body fat in the Reshape group. If body water was a major factor contributing to the weight loss, then the increased immunoglobulin levels in Wing's study could be partially attributed to hemoconcentration rather than an improved physiological response.

It is possible that the increased immunoglobulin responses observed by Wing et al may represent an acute stress (and adaptive metabolic) response similar to that resulting from an acute exercise bout; and hence, may represent a response to a potentially "life-threatening" condition. According to Nehlsen-Cannarella et al. (1991), these changes in immunoglobulins are transient; and the increased levels return to baseline concentrations within 24-48 hours after removal of the stimulus.

Cardiovascular Fitness

H:3 There will be an association between measures of cardiovascular fitness and immunoglobulins IgA, IgG, and IgM.

Many beneficial effects of regular exercise are well documented. The consensus of most physically active people is that they are healthier than the general population (Simon, 1984), yet the role and relationship of exercise on host defense mechanisms has yet to be

elucidated. Epidemiological studies (Paffenbarger, 1986; Garabrant et al. 1984; Gerhardsson et al. 1986; Vena et al. 1987; Frisch et al. 1985) lay the framework for research on the relationship of a physically active lifestyle in reducing the risk of cancer. The results of this dissertation research suggest that cardiovascular fitness might be related to immune function. IgM was significantly correlated with both group measures of cardiovascular fitness: mean exercise heart rate ($r=0.35$); and, mile walk times ($r=0.30$). None of the studies reported in the review of the literature entail direct correlations between immunoglobulins and fitness levels.

Measures of Stress

H:4 There will be an association between measures of stress and immunoglobulins IgA, IgG, IgM.

Current Self-Appraisal scores were the only indices of stress significantly associated with ($r=-0.38$) with IgA or any of the immunoglobulins. This significant inverse correlation was present among females, but not males. Since the mean scores were almost identical (females (33.6 ± 0.8), males (33.6 ± 1.2), combined (33.7 ± 0.9), the lack of a statistically significant correlation among males may have been due to the small number of male subjects (e.g., the correlations for males with IgA, IgG and IgM were 0.15, 0.36 and -0.23, respectively). No known studies parallel this dissertation study. In a cross-sectional study of 37 women (mean age 59.3), Irwin et al. (1987) found that the severity of depression was associated with impaired NK cell activity and changes in T-cell subpopulations. Changes in neurohormone levels may be the overriding factor, thus adversely affecting immune function.

H:5 A significant amount of the variability in the immunoglobulin levels will be explained by the selected components of lifestyle management.

Because increased age affects immune function (Winchurch, 1987), age was included as a predictor variable in the ANOVA models for each immunoglobulin. The lifestyle management components weight, mile walk times, dietary protein and fat when combined with age explained 37% of the variability of the IgG and IgM models.

Body weight did not consistently contribute to the model for IgM, thus not functioning as a true predictor of the variability of IgM. Dietary protein and fat did not significantly contribute to the variability in the model.

In summary, body weight and mile walk time consistently explained a significant part of the variability in the IgG and IgM model (respectively) after adjusting for variability contributed by age, weight, mile walk time, dietary protein, and dietary fat. Thus, body weight and mile walk time (as a measure of cardiovascular fitness) represent important factors affecting variation in IgG and IgM. Body weight and cardiovascular fitness can be effectively changed through behavior modification techniques, which are part of the objectives of the Reshape program.

Longitudinal Study

Impact of Reshape Program

The difference between week 0 and week 12 variables were calculated by subtracting week 12 from week 0. Thus, a negative mean difference value indicated that the value at week 12 was greater than the value at week 0. A summary of the results for the first seven hypotheses demonstrates that overall the Reshape program was quite effective.

H:6 Reshape participants will weigh less at week 12 than at week 0.

H:7 Reshape participants will have less body fat at week 12 than week 0.

H:8 Stress measures of Reshape participants will improve from week 0 to week 12.

H:9 Measures of cardiovascular fitness will improve from week 0 to week 12.

Body fat, body weight, and BMI all decreased significantly for the entire group and for males and females. Males tended to lose more weight and body fat than females. Two different measures of stress, the Current Self-Appraisal ($p \leq 0.01$) and State-Trait Anxiety ($p \leq 0.05$) changed significantly from week 0 to week 12. The hypothesis was accepted for both measures of stress for the entire Reshape group. The hypothesis was accepted for the Current Self-Appraisal instrument for males (-3.9 ± 0.08 points) but not for females. Average cardiovascular fitness levels improved for all three groups (i.e., all subjects combined, males and females) as evidenced by a significant decrease in the average time needed to walk a mile. The hypotheses were accepted for all three groups. Average exercise heart rates tended to increase (not-significant) between week 0 and week 12.

Bazzarre & Izlar (1986) examined many of the same variables of 11 insulin dependent diabetics successfully completing the Reshape program. The data of this dissertation study support the reported findings of Bazzarre et al (1985), and by Bazzarre and Izlar (1986); for significant weight loss, decrease in percent body fat, and improved cardiovascular fitness. Stress levels were not reported in these studies by Bazzarre and coworkers.

H:10 Reshape participants will reduce their dietary intake of fat.

Based on the eight sets of food records (week 0 and week 12), there was a significant decrease in energy intakes as a percentage of fat kilocalories ($-6.5 \pm 2.4\%$) and in total fat intake (24.3 ± 7.1 grams). Chandra (1988) lists numerous immune functions known to be affected by dietary fats. Barone et al. (1989) measured natural killer

cell activity of 17 males of normal body weight before and after a 3 month intervention diet low in polyunsaturated fatty acids (PUFA) and equating to less than 20% kilocalories, fat. NK cell activity significantly increased in this group. The change in total dietary fat was the most significant variable predicting NK-cell activity after adjusting for exercise, BMI, total calories, and baseline NK-cell activity. Thus, controlling/reducing dietary fat intake may favorably reduce coronary and chronic disease risk factors as well as impact health and immunity.

H:11 Reshape participants will increase their dietary intake of vitamins A, C, and E as well as beta-carotene.

The dietary intakes of vitamin A, C and E did not significantly increase from week 0 to week 12. Beta-carotene intake increased significantly (-424 ± 138 REs) by week 12. Average dietary intakes of beta-carotene were significantly higher at week 12. Beta-carotene intake was approximately two-times higher at week 12 compared to week 0. The dietary intakes of these nutrients varied widely among subjects. Thus, the small number of subjects and the large variance probably reduced the probability of finding any significant changes.

These data suggest that dietary adequacy was not impaired for any of the vitamins for the group at week 0 or week 12. Group intake levels of these vitamins at week 12 are indicative of modified food intake behavior or habits. Increasing dietary intakes of vitamins A, C, E and beta-carotene of benefit as antioxidants, modulators of PG_2 synthesis, preserving cell membrane function, and directly anti-tumorigenic (vitamin A) with cancer.

H:12 Reshape participants will increase their dietary intake of iron, zinc, and copper.

Average dietary intakes of iron, zinc and copper did not significantly change for the group. Thus, the hypotheses for iron, zinc and copper were rejected. These data suggest that dietary adequacy was not impaired for any of the trace nutrients for males, however the intakes of iron, copper and zinc for females were deficient. Iron and copper intakes increased at week 12, however, zinc intake decreased (Appendix H). The dietary deficits observed in this dissertation research (i.e., low iron and zinc status) are commonly associated with obesity (Chandra and Kutty, 1980). Zinc status for the females decreased between week 0 and week 12. This reduction in intake may have been due to the emphasis on increasing raw fruit and vegetable intakes. Increased bulk (fiber: due to the fruits and vegetables) may impair zinc absorption.

Summary of Reshape Program Impact

Behavior modification, nutrition education, and exercise are the most effective components of weight management programs (Hermann-Nickell, Baker, 1989). The results of this dissertation study support the established effectiveness of the Reshape program (Bazzarre et al, 1985; Bazzarre & Izlar, 1985). The Reshape program focus entails decreasing dietary fat intake, reducing caloric intake (300 kcal/day x 7 days per week) and concomitantly increasing energy expenditure (300 kcal/day x 5 days per week). Dietary fat is the most concentrated energy source available in the human diet. Participants successfully completing the Reshape program actually reduced their caloric intake to an amount approaching the program goal. Decreasing their percent of fat as kilocalories by 6.5% roughly translates to approximately 220 kcal from concentrated energy (fat).

The significant improvement in the group's fitness (increased energy expenditure) enhanced the energy deficit that promoted weight/fat losses. All three groups (males, females, total group) lost weight and body fat. In summary, reduced fat intake, improved cardiovascular

fitness, and stress reduction support the effectiveness of this program's behavior modification strategies.

What was the relationship between changes in the independent variables and changes in immunoglobulins?

CORRELATIONS WITH CHANGE VARIABLES

Correlations between mean differences or change variables (week 0 minus week 12) and changes in immunoglobulins were examined to identify synonymous trends with the immunoglobulins. In order to increase the statistical power of the following analyses, and because the immunoglobulins were not significantly different between males and females (except IgM), the results for the group (males and females combined) are discussed in this section.

Dietary

H:13, H:14, and H:15 were not accepted because no significant relationships were present between any of the immunoglobulins and the dietary variables (kilocalories, carbohydrates, protein, fat, percent of kilocalories from fat, protein, or fat, vitamins A, C, E, beta-carotene, iron, zinc, and copper). The low number of complete sets of food records probably interfered with the identification of any relationships between the dietary variables and the immunoglobulins. If the "n" were larger there may have been sufficient data to delineate trends between each dietary variable and the immunoglobulins. Several of the dietary variables (vitamin A, beta-carotene, and copper) not appearing in this dissertation writing approached significance, thus lending support to the above statement regarding the small number of complete food records.

Obesity

H:16 A reduction of body fat measures will be associated with changes in IgA, IgG, and IgM.

Changes in hip circumferences (r=-0.34) were negatively correlated with changes in IgA. Changes in IgG were positively associated (r=0.41) with the changes in percent body fat. Indices such as waist, hip circumferences, and WHR are being addressed by more researchers working with body composition analyses (Van Gaal et al. (1989). Relationships between waist and hip measures and chronic disease risk factors are becoming more evident as research results continue to examine the relationship between body fat and chronic disease development.

The study population of this dissertation research experienced a significant reduction in hip circumference (2.4 ± 0.8 cm; $p=0.01$) for the group by week 12. The hip area circumference tends to increase as body fat increases; however, with exercise training increased muscle circumference and decreased fat depots may result in changes in overall hip circumference. The relationship between changes in hip circumference and changes in IgA indirectly suggest a relationship between body fat and IgA. Large positive hip circumference change numbers represent large losses in body fat. Thus, an inverse relationship between IgA and hip circumference supports the relationship that increased body fat is associated with decreased IgA.

Everyone completing the Reshape program lost body fat (3.5 ± 0.5 %; $p \leq 0.001$). The larger the amount of body fat lost, the greater the change (positive increase) in IgG. Both of these correlations, one a direct relationship, the other indirect, serve as growing evidence that the changes in body fat experienced by this population are related to changes in immunoglobulin levels. Only one study lends any comparable information relevant to this dissertation research. Nehlsen-Cannarella, Nieman, Balk-Lamberton et al. (1991) reported no significant change in body weight, percent body fat, or VO_2 (measure of cardiovascular fitness) of the exercising group after a 15-week walking program. The group of 18 females (mean age: 36 years) were conditioned prior to the study and significantly increased their time

spent on the treadmill time for fitness testing. Although IgA, IgG, and IgM levels increased in the exercise group between weeks 0 and 15, there were no significant differences in immunoglobulin levels between the exercise and control groups. Body fat significantly decreased and cardiovascular fitness improved in the subjects in this dissertation research. These data support the hypotheses that decreased body fat and increased exercise are positively associated with changes in immunoglobulin levels.

Cardiovascular Fitness

H:17 Changes in measures of cardiovascular fitness will be associated with changes in IgA, IgG, IgM.

There were no significant correlations between the changes in measures of cardiovascular fitness and the immunoglobulins; however, both changes in exercise heart rate ($r=0.46$; $p \leq 0.06$) and changes in mile walk times ($r=-0.39$; $p \leq 0.07$) approached significance.

Immune response to exercise may be indirectly associated with hormonal factors. Improved cardiovascular fitness may modulate basal hormone levels (e.g., cortisol). White et al. (1976) compared serum cortisol levels of two groups (sedentary vs fit) of male subjects (mean age 44) before and after a four month fitness program. Serum cortisol levels of both groups were significantly higher during high intensity work-outs and during recovery. Even the low fitness group had lower cortisol levels than the controls.

MacNeil et al. (1991) examined the effects of fitness and exercise intensity on lymphocyte proliferation. Subjects were grouped according to fitness levels based on max VO_2 values. Each group contained 8 male subjects. The three groups and a control group were compared for lymphocyte response to acute exercise bouts of varying intensity (i.e. 60 minutes at 30% VO_2, 60 minutes at 75% VO_2) and duration (30 minutes at 65% VO_2,, 120 minutes at 65% VO_2). Cortisol levels across all rides were inversely related to the group fitness level. The higher the

fitness level of the group, the lower the overall cortisol levels. All three exercising groups had significantly higher cortisol levels than the control group. Cardiovascular fitness may enhance tolerance to the exercise stress exercise through lower serum cortisol levels. Subjects in this dissertation study demonstrated improved cardiovascular fitness levels through faster mile walk times. Future research should evaluate the relationship of changes in plasma cortisol values to changes in immunoglobulins.

One might conclude that the lack of significant correlation between the two changes in cardiovascular fitness and immunoglobulins might suggest that improved fitness can be achieved without any detrimental effects on immune status. Clearly, more research is needed before such a conclusion can be reached.

Measures of Stress

H:18 Changes in measures of stress (i.e. Recent Events Inventory, Current Self-Appraisal, and State-Trait Anxiety Inventory) will be associated with changes in IgA, IgG, IgM.

IgA was positively associated (r=0.50) with changes in the Current Self-Appraisal scores. Physiological stress (beneficial and detrimental effects) via exercise was addressed in H:17. Emotional of stress has been demonstrated to influence cortisol levels (Kiecolt-Glaser & Glaser, 1988). Both types of stress (psychological and physiological) are capable of influencing immune status. Watson (1989) has demonstrated the modulating effects of corticosteroid on interleukin production. Irwin (1987) has identified important relationships between depressed mental states and a reduction in natural killer cell activity. Current Self-Appraisal scores improved between week 0 and week 12. Higher stress scores indicate better self-satisfaction and happiness. Reshape participants actually have demonstrated a concerted effort to modify

their lifestyles in a positive manner. Successful attainment of their personal goals surely promotes happiness. Happiness is the opposite of depression. Perhaps the positive relationship between the changes in stress levels and IgA values serve as parallel indicators of improved immune status as well as successful attainment of Reshape program goals.

Impact of Reshape Program with Immunoglobulins

H:19 Immunoglobulins levels of Reshape participants will change from week 0 to week 12.

IgG decreased significantly (139.8 $\pm$ 65.1 mg/dl; $p \leq 0.05$) for males (Table 7). The hypothesis was accepted for IgG for males only. The concerted efforts of Nehlsen-Cannarella, Nieman & Balk-Lamberton et al. (1991); Nehlsen-Cannarella, Nieman & Jessen et al. (1991); MacNeil et al. (1991); Nieman et al. (1991) and Watson et al. (1986) are indicative of the current research endeavors regarding the relationship between exercise intensity, frequency and duration on the immune system. Nehlsen-Cannarella, Nieman & Balk-Lamberton et al. (1991) examined the immunoglobulin response of 36 sedentary, mildly obese women in a 15-week walking program. The exercise component of this program was quite similar to that of the Reshape program. Serum immunoglobulins IgA, IgG, and IgM increased 20% for the exercise group, but there was no significant difference between the control and exercise group at any point. Although the control group was not evaluated in this dissertation research, only IgA for females and IgG for males decreased significantly. The resulting change in immunoglobulins is in contrast with those changes reported by Nehlsen-Cannarella, Nieman & Balk-Lamberton et al. (1991). Using simple group differences expressed as a percentage, all immunoglobulin levels increased between weeks 0 and 15. However there were no significant differences between the control and exercise group. The following immunoglobulins levels of this

dissertation research are expressed as simple group differences. A (-) denotes values which decreased between weeks 0 and 12. Thus, the

Immunoglobulin	Group	Females	Males
IgA	4.2%	6.7%	-3.8%
IgG	2.3%	12.3%	-11.9%
IgM	-4.3%	0.6%	9.4%

statistical methodology used in expressing results between these two studies accounts for some of the differences.

Research examining the physiologic response of immunoglobulins is in its infancy. The lack of consistent significant improvements in Igs by week 12 may simply reflect normal variation in immunoglobulin levels.

The Reshape program goals include modifying lifestyle habits in a manner that minimizes physiological and psychological stress to the human body. The lack of significant changes across Igs may serve as evidence that the program was effective in achieving its goals of helping people learn how to modify chronic disease risk factors without disrupting normal immunoglobulin function.

LIMITATIONS OF THE STUDY

There were three primary limitations with this dissertation research; the small sample size, the loss of the control group, and the focus only on immunoglobulins as a single measure of immune function/status. A larger sample, an increase in the proportion of male subjects and a more even distribution of ages would have been ideal in order to have a more representative sample. The female:male ratio of this study was 31:16. A sample of 100 males and 100 females would have greatly strengthened the statistical power of this study as well as the multiple regression analyses.

The small number of food records (n=8) at week 12 was a major limitation of this study. Although these subjects paid to participate in the Reshape program, some type of renumeration or rebate available only after all endpoint evaluations were completed should have increased the compliance rate for collecting dietary information.

The loss of the control group was another example of how subjects can be lost without some type of motivation and incentives to return for an endpoint evaluation. Almost eighty percent of the participants completed the post-intervention evaluation. Additionally, training graduate students about the importance of completing the data collection process would enhance the post-intervention evaluation.

Immunological testing was extremely expensive. Funding, space and equipment limitations prevented a more complete evaluation of changes in immune function/status such as lymphocyte proliferation and natural killer cell activity.

Recommendations For Future Research

The data from this dissertation research provide the groundwork for identifying the relationships between the components of a proven effective lifestyle management program and a representative test of immune function. Although statistically significant relationships were found between body fat indices, cardiovascular fitness, stress, and dietary intake and one or more of the immunoglobulins, inferences are limited due to the small sample size and the lack of a control group. The tremendous divergent range in immunoglobulin levels within this dissertation study necessitates the use of a control group to minimize confounding variables. Alternatively, the use of a control group may simply illustrate the large inter and intra-subject variability in immunoglobulin concentrations.

The free living human model as a research subject in itself is confounding due to the complex functional interrelationships of different organ systems. More knowledge is learned daily about the

human system's adaptive responses to external stresses threatening homeostasis. Some variables such as heredity and aging cannot be changed. Many variables such as under and over nutrition, psychological stress, poor cardiovascular fitness can be modified, yet remain in harmony with a person's lifestyle.

As a body of knowledge immunology is in its infancy. The review of literature in this dissertation research is indicative of diversification of immune research and the limited knowledge base. Very few studies address immunoglobulins levels as an index of immune function. Little is known about a person's normal immunoglobulin fluctuation pattern. For example, do immunoglobulins fluctuate daily or seasonally? How quickly can the body respond to perceived stress in terms of increased Ig synthesis? Multiple samples taken over the intervention period would help determine the range of fluctuations on the immune parameters addressed in this study.

Secretory IgA (sIgA) was not measured as part of this research study. Tomasi et al. (1982) found significant decreases in sIgA levels in cross-country skiers after competition. What is the relationship between serum and secretory IgA? Loci of IgA are found at strategic locations in the body. They serve as reservoirs for conversion to sIgA. Since sIgA plays a non-specific role in maintaining the integrity of the body's first line defense (i.e. sebaceous, mucosal, bronchial, intestinal secretions) against foreign pathogens, sIgA would be the next logical step in examining the relationship of immunoglobulins with dietary intake, obesity, cardiovascular fitness, and stress. It would be of value to measure secretory and serum IgA levels if this study were repeated.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This dissertation research examined the relationship between select dietary intakes, obesity, cardiovascular fitness, and stress among participants of the Reshape program and immunoglobulins IgA, IgG, and IgM (measures of immune function). Reshape is a 12-week intervention program which promotes lifestyle management through behavior modification of dietary nutrient intake, body fat composition, cardiovascular fitness, and stress.

This investigation consisted of a cross-sectional and longitudinal component. A sample of 47 subjects (31 females and 16 males) were recruited and evaluated at week 0 for the cross-sectional study. Correlations were calculated to identify any significant relationships between the population's immunoglobulin levels and their initial status with respect to dietary intakes, obesity, cardiovascular fitness, and stress. Analysis of variance (multiple regression) was computed to determine the relative contribution of the lifestyle management components on the variability in IgA, IgG, and IgM levels. Hypotheses H:1 through H:5 addressed the cross-sectional aspect of this dissertation research.

The longitudinal study measured the Reshape program impact on changing the aforementioned variables, i.e. dietary intakes, obesity, cardiovascular fitness, and stress. Thirty-six people completing the Reshape program were evaluated in the longitudinal component. Correlations were calculated to identify any significant relationships between changes in immunoglobulins and group changes with respect to dietary intakes, obesity, cardiovascular fitness, and stress. Hypotheses H:6 through H:12 examined the changes attributable to successful completion of the Reshape program. Correlations between

those changes in the independent variables (dietary intake, obesity, cardiovascular fitness, stress and changes in the immunoglobulins were addressed in hypotheses H:13 through H:18. The last hypothesis H:19 addressed the longitudinal impact of the Reshape program on the immunoglobulins.

The results of this dissertation are summarized in the same order as the hypotheses following a brief description of the subjects at week 0. Forty-seven subjects (31 females, 16 males) between the ages of 17 and 89 had an average of 33.8 $\pm$ 0.08 percent body fat and weighed 82.1 $\pm$ 3.1 kg (180.6 lbs). The nutrient intake for the group was 1926 $\pm$ 101 kilocalories (47% carbohydrates, 16% protein, 36% fat). Dietary intakes were well below the RDA for iron (12.3 $\pm$ 0.6 mg), zinc (9.9 $\pm$ 0.6 mg), copper (1.3 $\pm$ 0.1 mg) and beta-carotene (428.9 $\pm$ 53.8 RE). Biochemical indices for IgA, IgG, IgM, and hematocrit were within normal ranges.

CROSS-SECTIONAL STUDY:

What was the relationship between the independent variables (lifestyle management components) and immunoglobulin levels of this population at the beginning of the Reshape program?

Significant inverse correlations were found between the following dietary intakes and IgM for the group: kilocalories (r=-0.32), grams of protein (r=-0.32), grams of fat (r=-0.32), iron (r=-0.33) and copper (r=-0.34) and for vitamin E (females; r=-0.48). Dietary intakes for males were positively correlated: vitamin A (IgA; r=0.63), vitamin C (IgA; r=0.71) and vitamin E (IgM; r=0.60). IgM was positively correlated with body weight and BMI for the group and females, while IgM was negatively correlated with percent body fat for females. No significant relationships were found for indices of body fat with males.

Both indices of cardiovascular fitness were significantly correlated with IgM values for the group: (exercise heart rate; r=0.35) and (mile walk time; r=0.30). Current Self-Appraisal scores (stress

evaluation) were inversely correlated with IgA for females only (r=-0.38). ANOVAs (multiple regression) explained 37% of the variability in both IgG and IgM levels by the combination of weight, mile walk times, dietary protein and dietary fat. Weight and mile walk times significantly contributed to the variability of the IgG and IgM models (respectively) after adjusting for all other variables in the model.

LONGITUDINAL STUDY:

What changes occurred in the lifestyle management components (chronic disease risk factors) after completing the Reshape program?

In the longitudinal component of this study, successful completion of the Reshape program yielded significant decreases in all three indices of obesity for all three groups. The Reshape group lost an average of: 3.5 $\pm$ 0.7 kg body weight (females:2.2 $\pm$ 0.6 kg; and males:5.6 $\pm$ 1.5 kg); and 3.5 $\pm$ 0.5 percent body fat (females:2.2 $\pm$ 0.4; and males:5.1 $\pm$ 0.9). BMI decreased 1.2 $\pm$ 0.2 (females:0.86 $\pm$ 0.2; and males:1.7 $\pm$ 0.4). Waist (0.6 $\pm$ 1.8 cm) and hip (2.4 $\pm$ 0.8 cm) circumferences also decreased significantly. Stress indicators (group) as measured by the Current Self-Appraisal and State-Trait Anxiety Inventory improved a mean difference of -2.3 $\pm$ 0.8 and 3.1 $\pm$ 1.4, respectively. Stress levels (State-Trait Anxiety; -3.9 $\pm$ 0.8) improved significantly for males only. Cardiovascular fitness improved significantly as measured by mean mile walk times (group: 1.2 $\pm$ 0.2; females: 1.2 $\pm$ 0.2; and, males: 1.3 $\pm$ 0.2). Reshape participants significantly reduced their dietary fat intake (24.3 $\pm$ 7.1 grams) and the percent kilocalories consumed as fat (6.5 $\pm$ 2.4). Beta-carotene (-424 $\pm$ 1138 RE) intake significantly increased by week 12 for the group. There were no significant increases in vitamin or mineral intakes.

LONGITUDINAL CORRELATIONS:

What was the relationship between the changes in lifestyle management components and changes in immune function (immunoglobulins)?

There were no significant correlations between any of the immunoglobulin changes and changes in dietary fat, vitamins, or minerals, probably due to the small number of diet records evaluated for both weeks 0 and 12. Two significant relations between changes in body fat were identified: for hip circumference change; (IgA; r=-0.34) and for body fat change (IgG; r=0.41). There were no significant correlations associated with changes in cardiovascular fitness. Current Self-Appraisal stress scores (r=0.50) were correlated with changes in IgA. A significant longitudinal decrease in immunoglobulin levels occurred only for males (IgG; 139.8 $\pm$ 65.1 mg/dl). Longitudinal changes in immunoglobulins, expressed as percent changes, increased for 6 of the 9 groups (minimum increase: IgM; group, 0.6% to maximum increase: IgG; females, 12.3%). Immunoglobulins decreased by week 12 for three of nine groups: IgA for males: 3.8%; IgG for males: 11.9%; and, IgM for group, 4.3%.

The cross-sectional component of this dissertation research identified significant relationships between lifestyle management components and immunoglobulin levels characteristic of the population at week 0. Negative relationships were found between select dietary intakes (kilocalories, protein, fat, iron, copper, vitamin E) and IgM for the group and females. A positive relationship was observed between vitamins A, C, E and IgA, IgM for males. Implications from these relationships support findings in the literature that excessive nutrient intakes can impair immune function. It is postulated that the positive association with vitamins A, C, and E and IgA, IgM indicate a threshold effect for males, (i.e., the intakes of this male population had not reached the "excess" intake level). Body weight and BMI were positively related to IgG for the group and for females. Excess weight and weight

for height proportions may impair immune function as reflected by elevated immunoglobulin values. Body fat for females was associated with decreased IgM levels as body fat percent increased. Both measures of cardiovascular fitness were positively correlated with IgM. Implications from this correlation are that individuals who are less fit tend to have higher immunoglobulin levels. ANOVAs (multiple regression) indicated that body weight (obesity component) and mile walk time (cardiovascular fitness) were important factors contributing to the explained variability in IgG and IgM (respectively) levels of the population at week 0.

Significant improvements in the lifestyle management components (i.e., improved dietary intakes, cardiovascular fitness, stress levels and reduction of weight and body fat), were experienced by the Reshape population over the 12 week program. Correlations between changes in those lifestyle components (decreases in dietary fat and body fat, improvements in cardiovascular fitness and stress levels) and changes in immumoglobulins verified important relationships in the cross-sectional correlations at week 0. As evidenced by the relationship of changes in hip circumference and changes in body fat with changes in IgA, IgG, respectively; body fat was clearly the most important component of lifestyle management associated with changes in immunoglobulins.

The data from this research dissertation suggest that the relationship between high body fat levels and immunoglobulins is one that needs further research. Immunoglobulin levels of this population reflect a tremendous range in variability. The lack of overall significant differences in the immunoglobulin levels as a result of the Reshape program is postulated to be an important indicator of the effectiveness of modifying chronic disease risk factors in a lifestyle management program without inciting acute changes in immunoglobulins.

Use of incentives to encourage control group compliance and completion/return of dietary food records would contribute greater

statistical power in future studies. Very little information is known about physiological fluctuations in immunoglobulin levels. Is there a threshold for changes body fat levels and immunoglobulins? If a threshold exists, is it sex specific and independent of other factors, i.e., stress and exercise? Further research is needed to elucidate the relationships between obesity and immunoglobulins.

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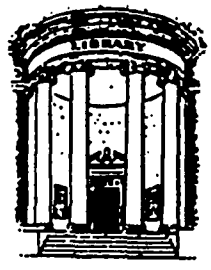
APPENDIX A

INFORMED CONSENT



THE UNIVERSITY OF NORTH CAROLINA
AT GREENSBORO

SCHOOL OF HUMAN ENVIRONMENTAL SCIENCES

Department of Food–Nutrition–Food Service Management
(919) 334-5332; 5313

CONSENT FORM

I agree to participate in the study "Nutritional Status, Energy Expenditure and Chronic Disease Risk Factors Among Reshape Participants of Spring 1990 which is being directed by Dr. Terry Bazzarre, and two doctoral students (Rita Sigmon and Lizette Sanchez).

EXPLANATION OF STUDY

I understand that the purpose of this study is to measure food intake, physical activity, stress, blood pressure and the levels of various constituents such as cholesterol, iron, zinc, vitamin C, and immunoglobulins present in the blood. I understand that the above measurements will enable Dr. Bazzarre and his colleagues to study the relationships of diet and physical activity to health and to disease problems such as cardiovascular heart disease, high blood pressure and diabetes. I understand that I will need to complete a questionnaire about my personal and familial medical health in order for Dr. Bazzarre to conduct his study.

METHODS

I understand that a 4-day food record which I will complete at home will be used to estimate my intake of 25 nutrients. I understand that a 4-day activity record that I will complete at home will be used to measure my energy expenditure for physical activity. I understand that questionnaires will be used to collect information about my personal and family medical histories as well as to assess the amount of stress I have experienced in my life during the past year. I understand that these questionnaires will be reviewed and completed at my first visit. The food records and activity records will be explained to me at visit I.

I understand that my blood pressure will be measured using a standard blood pressure cuff. I understand that about 30 ml (5 tablespoons) of blood will be collected to measure the cholesterol, iron, zinc, immunoglobulin, insulin, glucose and vitamin C in my blood. I understand that the risks of having by blood drawn include fainting, bruising, air emboli, puncture of an artery instead of a vein and compression of a nerve. I understand that

Dr. Bazzarre will draw blood following appropriate blood drawing techniques and will make every effort to avoid causing any of the above risks. I understand that my blood pressure will be measured and that the blood sample will be collected at visit II. I understand that I will return the food record and activity record at visit II. I understand that skinfold thickness measurements will be taking at four body sites.

CONFIDENTIALITY

I understand that a code number rather than my name will be used to identify the information I provide to the researchers, and that my name and code number will be linked only on raw data forms. These forms will be kept securely in a file cabinet. I also understand that I may withdraw from the study at any time of my choosing without prejudice form any of the investigators.

EXPLANATION OF BENEFITS

The benefits I may gain form participating in this study include: evaluation of my risk of developing heart disease, hypertension, or nutrition problems; evaluation of my stress levels, resistance to diseases, and measurements of my body fat. I will also receive a written report containing all my measurements upon the completion of the study. I understand that the benefits of participating in this research outweigh the potential risks which are not likely to occur.

I understand that Dr. Bazzarre or his designee will be able to answer any questions I have. They can be reached at 919-334-5332 during the weekdays. All of my immediate questions have been answered.

_____ _____

SIGNATURE (FULL LEGAL NAME) Date

_____

SIGNATURE OF RESHAPE STAFF MEMBER

APPENDIX B

MEDICAL HISTORY QUESTIONNAIRE

MEDICAL INFORMATION
Dr. Terry L. Bazzarre

Date _____

RESHAPE

NAME _____ Address _____

_____

R _ _ _ _ _ _ _ _ _ Telephone No(s): Home - _____
1 5 6 7 8 Year Work - _____
I.D. No. Session 1 = Fall 2 = Spring 3 = Summer 4 = Private Client

Sex: _ 1 = Male _ 2 = Female

9

Race: _ 1 = Black _ 2 = White _ 3 = Other

10

Physician's Clearance: (PHYSCL)

If client is over 35 years of age or has CHD, diabetes or hypertension, give the client, the physician's clearance forms.

_____
Name of physician

_ 0 = Not approved
_ 1 = Approved 11
_ 2 = Approved w/ exercise stress test performed
_ 3 = Approved for walking only
_ 4 = Other (Specify): _____
_ 5 = Not Applicable (i.e. client is under 35 years of age with no medical history of CHD, hypertension or diabetes)

Occupation: (OCCU)

Ask client to describe their current occupation. If retired, ask client to describe their occupation prior to retirement.

_____

_ 01 = Housewife
_ 02 = Student 12 13
_ 03 = Health professional (e.g., MD, RN, RD, dentist, psychologist)
_ 04 = Administrator/ Lawyer
_ 05 = Secretary/ Clerical
_ 06 = Blue Collar (e.g., mechanic, gardener)
_ 07 = Sales/ Service (e.g., social worker)
_ 08 = Farmer
_ 09 = Teacher/ Educator
_ 10 = Technical/ Engineer/ Computer Programmer
_ 11 = Other (Specify): _____

Marital Status: (MARITAL)

_ 1 = Married
_ 2 = Single 14
_ 3 = Divorced/ Separated

AGE: (AGE) years (Ask client for date of birth: _/_/_)

15 16

MEDICAL INFORMATION
Page 2 Date _____

NAME _____ (I.D. NO. R _ _ _ _ _)

Height: (HEIGHT) record in inches _ _ . _ 17 20
1/4" = .3 in
1/2" = .5 in
3/4" = .8 in

Goals: (GOALS) 21
Please ask client to describe his/ her goals:-
(1) _____
(2) _____
(3) _____
(4) _____
_____
_____

1 = Weight loss
2 = Fitness
3 = Diet
4 = Stress Management
5 = Weight loss + Fitness (1 & 2)
6 = Weight loss + Diet (1 & 3)
7 = 1,2 & 3
8 = 1,2,3 & 4
9 = Other (Specify)

Goals for Weight Loss: (GLWTLOSS) _ _ _ 22 24
If the client plans to lose wt during the program, write the number of pounds s/he plans to lose during the program. If the subject does not plan to lose any weight, write " 000 " in columns 22 - 24.

Children: (CHILDREN) Write down the number of children. _ 25

Write down the age of the oldest child. _ _ 26 27

Write down the age of the youngest child. _ _ 28 29

List names, ages and sex of all children.

MEDICAL INFORMATION
Page 3 .

Date

NAME _____ (I.D. NO. R _ _ _ _ _)

PERSONAL MEDICAL HISTORY

For each of the following chronic diseases mark: 1 = present
2 = absent
3 = unknown

Coronary Heart Disease (PCHD) _ 30

Hypertension (PHYP) _ 31

Diabetes (PDIA) _ 32

Obesity (POBESITY) _ 33

Ask the client if s/he has any other major medical problems.
Please list: _____ _ 34
(POTHER) _____
_____
_____

0 = None
1 = Cancer
2 = Mental Health (e.g. depression)
3 = Arthritis
4 = Gastro-Intestinal
5 = Endocrine
6 = Respiratory (e.g. asthma, allergies
7 = Dermatological
8 = Other

Smoking History: (SMOKE) 0 = Never
1 = Stopped _ 35
2 = Yes

If the individual stopped smoking, how many years ago did they stop? (YRSAGO) _ _ 36 37

If the individual currently smokes, how many packs/ day does s/he smoke? (PKSDAY) _ 38

If the individual currently smokes, how many years has s/he smoked? (YRSSMOKED) _ _ 39 40

MEDICAL INFORMATION
Page 4

Date _____

NAME _____ (I.D. NO. R _ _ _ _)

Alcohol intake: (ALCOHOL) 0 = Never
1 = Yes _ 41

If yes, describe the amount of the following beverages consumed.

Beer (No. of 12 oz cans/ week) (BEER) _ _ 42 43

Wine (No. of 3 oz glasses/ week) (WINE) _ _ 44 45

Mixed Drinks (No. of 2 oz servings/ week) (MIXED) _ _ 46 47

Note: Use 0 if they never consume any of the above category of alcoholic beverages. Use 1 if s/he consumes the beverage between once/ year and once/ week.

History of Obesity:

Ask client if s/he considers herself or himself overweight? _ (OVWT) 48
1 = yes
2 = no

If s/he considers herself or himself overweight, ask client how many pounds s/he is overweight? AND _ _ _ (XTRAWT) 49 50 51

how many years s/he has been overweight? _ _ (YRSOVWT) 52 53

RESHAPE

NAME: _____ (I.D. NO. R 1 _ _ _ _ 5) Date: _____

INITIAL DATA: VARIABLE:	WEEK 0	WEEK 12	FOLLOW-UP DATA: 9 (# Wks p program)	
Body Weight (pounds)	54 _ _ ÷ 58	59 _ _ ÷ 63	35 _ 37 / 38 _ _ ÷ 42	(THRWT)
Waist (inches)	_ _ ÷ _ / 64 67	_ _ ÷ _ / 68 71	_ _ ÷ _ / 43 46	(THRWAIST)
Thigh (inches)	_ _ ÷ _ / 72 75	1* / 79 _ _ ÷ _ / 6 9	_ _ ÷ _ / 47 50	(THRTHIGH)
Biceps (mm)	_ _ ÷ _ / 10 13	_ _ ÷ _ / 14 17	_ _ ÷ _ / 51 54	(THRBICEP)
Triceps (mm)	_ _ ÷ _ / 18 21	_ _ ÷ _ / 22 25	_ _ ÷ _ / 55 58	(THRTRICP)
Subscapular(mm)	_ _ ÷ _ / 26 29	_ _ ÷ _ / 30 33	_ _ ÷ _ / 59 62	(THRSUBSC)
Suprailiac (mm)	_ _ ÷ _ / 34 37	_ _ ÷ _ / 38 41	_ _ ÷ _ / 63 66	(THRSUPRA)
Sum of 4 Skinfolds	_ _ _ ÷ _ / 42 46	_ _ _ ÷ _ / 47 51	_ _ _ ÷ _ / 67 70	(THRSKIN)
% Body Fat	_ _ ÷ _ / 52 55	_ _ ÷ _ / 56 59	_ _ ÷ _ / 71 74	(THRPBFAT)
Blood Pressure:				
Systolic (mm Hg)	_ _ _ / 60 62	_ _ _ / 63 65	_ _ _ / 75 77	(THRSYSBP)
Diastolic (mm Hg)	_ _ _ / 66 68	_ _ _ / 69 71	_ _ _ / 6 8	(THRDIABP)
Total Cholesterol (mg%)	_ _ _ / 72 74	_ _ _ / 75 77	2** / 79 _ _ _ / 9 11	(THRTC)
HDL-Cholesterol (mg%)	_ _ _ / 6 8	_ _ _ / 9 11	_ _ _ / 12 14	(THRHDLC)
Hematocrit (%)	_ _ / 12 13	_ _ / 14 15	_ _ / 15 16	(THRHTC)
Exercise Heart Rate (BPM)	16 17	18 19	17 18	(THRXHR)
Resting Heart Rate (BPM)	20 21	22 23	_ _	(THRRHR)
12 Minute Walk/Run (Miles)	24 ÷ 26	27 ÷ 29	21 ÷ 23	(THRMILES)
Activity Sessions Attended:	30 31	Workshops Attended: 32 33	4	(END LINE 4)

APPENDIX C

PHYSICIAN'S CLEARANCE FORMS

THE UNIVERSITY OF NORTH CAROLINA
AT GREENSBORO

School of Home Economics

Dear _____
(Physician's Name)

_____ is being screened for participation in
(Participant's Name)
the RESHAPE program sponsored by the departments of Nutrition, Physical Education, and Psychology at UNC-Greensboro. Part of our screening procedures require that we individually contact the physician of all participants over 35 years of age, and any participant who has known medical risk factors (e.g. high blood pressure, elevated fasting cholesterol, angina, etc.) before they begin the program.

We would like you to review the medical records of the above participant, conduct any necessary tests, and complete the attached form. Please mail the completed form to:

Dr. Terry L. Bazzarre, Director
RESHAPE
School of Home Economics
UNC-Greensboro
Greensboro, NC 27412

You can contact Dr. Bazzarre or members of the RESHAPE staff by calling 334-5332.

We have also attached, for your information, a letter which briefly explains the RESHAPE program. We have been approved as a service provider for weight reduction by the State Medical Director of Vocational Rehabilitation.

Thank you for your assistance.

Sincerely,

Terry L. Bazzarre, Ph.D.
Associate Professor

TLB:mr

Enclosure:

ATTACHMENT I

_____
(Date)

Dr. Terry L. Bazzarre
RESHAPE
School of Home Economics
UNC-Greensboro
Greensboro, NC 27412

Dear Dr. Bazzarre,

I have reviewed the medical records of

_____
(name of RESHAPE participant)

and reached the following opinion.

Check as appropriate:

_____ May participate in the RESHAPE program without any known medical risk

_____ May participate in the RESHAPE program only after the following tests have been satisfactorily completed

(1) _____ exercise stress test scheduled for the following date _____
Month Day Year

(2) _____ Other tests: (please specify)

_____

_____

_____ May not participate in the RESHAPE program because of the following medical problems:

_____

_____

_____

_____

Sincerely,

_____
(Signature)

_____
(Office Telephone Number)

APPENDIX D

MEDICAL FORM: IMMUNITY CLEARANCE

MEDICAL QUESTIONNAIRE

Please answer the following questions to the best of your knowledge so as to aid our evaluation of your laboratory measures. Feel free to use the back of this page for additional explanation of any of the questions.

1. _____ Do you presently have a cold, sore throat, or flu-like symptoms?

2. _____ When was the last time you were sick, or felt like you had a temperature?

3. _____ On the average, how many colds, or viruses do you "catch" yearly? Are they seasonal, i.e. "every March I end up getting sick", or sporadic?

4. _____ How would you rate yourself in terms of "catching something from being around someone who is sick or has the flu, etc." 1 = rarely catch something, to 10 = catch everything.

5. _____ When was the last time you had an operation? Briefly list when and the type of surgery?

6. _____ Have your ever been told by your doctor that you have any type of immune dysfunction or disease?

7. _____ Do you have any type of allergies? If so please list them and what you do for them?

8. _____ Have or are you currently on any type of medications? If so, please list types taken in the last year.

9. _____ When you get sick with a cold or flu, do you usually see a doctor and end up taking antibiotics?

APPENDIX E

TABLE FOR ESTIMATING PERCENT BODY FAT

APPENDIX F

IMMUNOGLOBULIN ASSAY

APPENDIX G

WRITTEN STRESS EVALUATIONS

APPENDIX H

CORRELATIONS AND DESCRIPTIVE STATISTICS

Appendix H Table H-1

Select Vitamin and Mineral Intakes (Means + SEM) of Reshape Subjects at Week 12

Variable	Total (n=8)	Females (n=5)	Males (n=3)
Vitamins:			
Vitamin A (RE)	2340 ± 801	1232 ± 318	4187 ± 1712
(Range)	(511-7552)	(511-2243)	(1953-7552)
Carotene (RE)	834 ± 291	672 ± 270	1103 ± 700
(Range)	(149-2502)	(149-1703)	(401-2502)
Vitamin E (mg)	11.9 ± 1.5	11.0 ± 2.0	13.0 ± 2.0
(Range)	(6.6-19.4)	(7-19)	(10-17)
Vitamin C (mg)	156.8 ± 31.6	106.0 ± 32	241.0 ± 12
(Range)	(54.9-257)	(55-227)	(218-257)
Minerals:			
Iron (mg)	16 ± 2.8	12 ± 3.0	23 ± 4.0
(Range)	(6-28)	(6-19)	(15-28)
Zinc (mg)	11.3 ± 1.9	8.1 ± 1.8	16.7 ± 0.8
(Range)	(3.8-17.6)	(3.8-13.1)	(15.1-17.6)
Copper (mg)	1.4 ± 0.3	1.1 ± 0.2	1.8 ± 0.7
(Range)	(0.5-3.1)	(0.5-2.0)	(0.9-3.1)

Appendix H: Table H-2

Anthropometric Data (Means ± SEM) for Reshape Subjects at Week 12

Variable	Total (n=36)	Females (n=21)	Males (n=15)
Weight (kg) (Range)	82.6 ± 3.3 (54-135)	72.0 ± 3.2 (54-108)	97.0 ± 4.0 (73-135)
BMI (wt/ht^2) (Range)	28.4 ± 0.9 (19.9-39.7)	27.2 ± 1.1 (20-40)	30.1 ± 1.4 (23.8-39.7)
Body Fat (%) (Range)	31.0 ± 1.03 (13-40)	3.9 ± 0.8 (26.6-40)	26.0 ± 1.8 (13-39.8)
Waist Circumference (cm) (Range)	100.0 ± 2.0 (76-135)	96.3 ± 3.0 (76-133)	106.0 ± 3.0 (89-135)
Hip Circumference (cm) (Range)	108.0 ± 2.0 (91-136)	109.0 ± 3.0 (91-136)	108.0 ± 3.0 (93-134)
Waist/Hip Ratio (Range)	0.93 ± 0.01 (0.79-1.1)	0.89 ± 0.01 (0.79-0.98)	0.98 ± 0.01 (9.8-1.07)

Appendix H: Table H-3

Select Nutrient Intakes (Means + SEM) of Reshape Subjects at Week 12

Nutrient	Total (n=8)	Females (n=5)	Males (n=3)
Kilocalories (Range)	1552 ± 172 (598-2283)	1356 ± 209 (598-1853)	1878 ± 214 (1555-2283)
Carbohydrates (Range)	213 ± 25 (61-289)	193 ± 25 (61-260)	246 ± 23 (210-289)
Protein (g) (Range)	75 ± 11 (30-117)	60 ± 10 (30-84)	101 ± 12 (78-117)
Fat (g) (Range)	50 ± 6 (27-79)	45 ± 7 (27-68)	59 ± 10 (46-079)
Fiber (g) (Range)	19.8 ± 2.5 (5.6-27.7)	19.0 ± 3.4 (5.6-27.7)	22.0 ± 3.0 (17-27)
Percent of Kcal:			
Carbohydrates (Range)	52 ± 2 (40-64)	53 ± 4 (40-64)	52 ± 1 (49-54)
Protein (Range)	19 ± 1 (13-23)	17 ± 2 (13-23)	21 ± 1 (20-23)
Fat (Range)	29 ± 2 (21-40)	30 ± 4 (21-40)	59 ± 10 (46-79)

Appendix H: Table H-4

Select Biochemical Measures (Means + SEM) of Reshape Subjects at Week 12

Variable	Total (n=35)	Females (n=20)	Males (n=15)
IgA (mg/dl) (Range)	194.1 ± 16.5 (78-529)	204.4 ± 26 (85-529)	180.0 ± 18 (78-274)
IgG (mg/dl) (Range)	1002.9 ± 47 (463-1500)	1019.5 ± 58 (463-1500)	981.0 ± 79 (463-1430)
IgM (mg/dl) (Range)	147.0 ± 1 (18-439)	198.3 ± 23 (36-439)	79.0 ± 13 (18-180)
Hematocrit (%rbc) (range)	46 ± 0.7 (38-55)	43 ± 0.5 (38-47)	50 ± 0.8 (43-55)

Appendix H: Table H-5

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Select Variables for All Subjects at Week 12 with P-value < 0.15

Variable	IgA	IgG	IgM
Anthropometric (n=35):			
Age	-	-0.43*	-0.38*
Weight	-	-	-0.27
Hip Circumference	0.28	-	-
Waist:Hip Ratio	0.28	-	-0.41*
Exercise (n=17):			
Ex. Heartrate	-	0.77*	-
Stress: (n=27):			
Current Self-Appraisal	-	-	-0.36
Biochemical (n=35):			
IgG	-	-	0.42*
Hematocrit	-	-	-0.41*

Appendix H: Table H-6

Pearson Correlation Coefficients Between Immunoglobulins IgA, IgG, and IgM and Select Variables by Gender at Week 12 (P-value < 0.15)

Variable	IgA	(n)	IgG	(n)	IgM	(n)
Anthropometric:						
Age	-		-0.57	(n=20)*	-0.47	(n=20)*
Weight	0.49	(n=15)#	0.42	(n=19)	-	
Body Mass Index	-		0.34	(n=19)	-	
Percent Body Fat	0.36	(n=18)	-		-	
Waist	-		0.40	(n=19)	-	
Hip	0.39	(n=15)#	0.40	(n=19)	0.34	(n=34)
Waist:Hip Ratio	-0.38	(n=19)	-		-	
Biochemical:						
IgG	-		-		-0.57	(n=20)*
Hematocrit	-		0.41	(n=15)#	-	
Exercise:						
Ex. Heartrate	-		0.89	(n=7)#*	0.85	(n=10)*
Stress:						
Holmes & Rahe	-		-		-0.38	(n=-20)

* $p \leq 0.05$
# male subjects

Appendix H: Table H-7

Stress and Exercise Values (Means + SEM) for Reshape Subjects at Week 12

Variable	Total (n)	Females (n)	Males (n)
Stress:			
Current Self-Appraisal	35 ± 1 (29)	34 ± 1 (17)	37 ± 1 (12)
(Range)	(24-45)	(24-45)	(30-43)
State-Trait	32 ± 1 (35)	33 ± 2 (21)	31 ± 2 (14)
(Range)	(20-47)	(20-46)	(21-47)
Exercise:			
Heartrate			
beats/10 seconds	25 ± 1 (22)	25 ± 1 (15)	26 ± 1 (7)
(Range)	(21-32)	(21-32)	(21-29)
Mile Walk Time			
minutes	14.7 ± 0.3 (28)	15.2 ± 0.4 (18)	13.7 ± 0.4 (10)
(Range)	(11.5-19.8)	(12.3-19.8)	(11.5-15.5)