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Emotional Health and Weight Gain: A Prospective Study of Middle-Aged Women

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EMOTIONAL HEALTH AND WEIGHT GAIN: A PROSPECTIVE STUDY OF MIDDLE-AGED WOMEN

by

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GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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As chair of the candidate's graduate committee, I have read the thesis of Ann Bahr in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

EMOTIONAL HEALTH AND WEIGHT GAIN: A PROSPECTIVE STUDY OF MIDDLE-AGED WOMEN

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The objective of this study was to investigate the extent to which risk of gaining weight or body fat is affected by emotional health in women. A secondary objective was to determine the influence of age, baseline weight and body fat, physical activity (PA), energy intake, and changes in PA and energy intake, on the relationship between emotional health and gains in weight and body fat.

The study was a prospective cohort investigation over 20 months of 256 healthy, non-obese females (age: 35-45 y, BMI < 30 kg/m^2). All subjects were assessed for several variables using objective measurements at baseline and again at 20 months. Emotional health was assessed using the General Well-Being Schedule. Body fat percentage was indexed using the Bod Pod. PA was measured objectively using MTI (CSA) accelerometers, and energy intake was measured using weighed, 7-day food records.

The results of the study demonstrated that risk of gains in weight and body fat were no greater in depressed women compared to their counterparts. However, 171 (66.8%) subjects demonstrated less than positive (LTP) emotional health at baseline, and 37.4% of these subjects gained weight during the 20-month study. Conversely, 85 (33.2%) subjects had positive emotional health at baseline, but only 23.5% gained weight over the investigational period. With no variables controlled, women with LTP emotional health had 59% greater risk of weight gain over the study period than women with positive emotional health (RR 1.59, 95% CI = 1.04-2.44). Women with LTP emotional health were at no greater risk of gains in body fat percentage than women with positive emotional health (RR 0.96, 95% CI = 0.70-1.33). After adjusting for each potential confounder individually, risk of gaining weight or body fat did not change. However, after adjusting for all of the potential confounders simultaneously, risk of weight gain was weakened (RR 1.43, 95% CI = 0.93-2.21).

These results seem to demonstrate that middle-aged women with LTP emotional health may be at increased risk of gaining weight compared to women with positive emotional health.

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Emotional Health and Weight Gain: A Prospective Study of Middle-aged Women

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Abstract

***Objective**:* Investigate the extent to which risk of gaining weight or body fat is affected by emotional health in women. Also, determine the influence of age, baseline weight and body fat, physical activity (PA), energy intake, and changes in PA and energy intake, on the relationship between emotional health and gains in weight and body fat.

Design: Prospective cohort investigation over 20 months.

Subjects: 256 healthy, females (age: 35-45 y, BMI < 30 kg/m^2).

Measurements: Emotional health was assessed using the General Well-Being Schedule. Body fat percentage was indexed using the Bod Pod. PA was measured objectively using MTI (CSA) accelerometers. Energy intake was measured using weighed, 7-day food records.

Results: Risk of gains in weight and body fat were no greater in depressed women compared to their counterparts. However, 171 (66.8%) subjects demonstrated less than positive (LTP) emotional health at baseline, and 37.4% of these subjects gained weight during the 20-month study. Conversely, 85 (33.2%) subjects had positive emotional health at baseline, but only 23.5% gained weight over the investigational period. With no variables controlled, women with LTP emotional health had 59% greater risk of weight gain over the study period than women with positive emotional health (RR 1.59, 95% CI = 1.04-2.44). Women with LTP emotional health were at no greater risk of gains in body fat percentage than women with positive emotional health (RR 0.96, 95% CI = 0.70-1.33). After adjusting for each potential confounder individually, risk of gaining weight or body fat did not change. However, after adjusting for all of the potential confounders simultaneously, risk of weight gain was weakened (RR 1.43, 95% CI = 0.93-2.21).

Conclusion: Middle-aged women with less than positive emotional health may be at increased risk of gaining weight compared to women with positive emotional health.

Keywords: Weight gain, emotional health, depression, physical activity, dietary intake

Introduction

It is well established in the literature that the prevalence of obesity and overweight have become major health problems in the United States.[1] In addition, obesity is one of the most costly health problems in the country.[2] Both overweight and obesity are linked to several chronic diseases including, hypertension, hypercholesterolemia, type II diabetes, heart disease, osteoarthritis, and gallbladder disease.[3] In 1998, it was stated that "obesity will probably replace cigarette smoking as the major killer of Americans in the next century."[4]

The treatment and prevention of obesity has proven to be very difficult, partly because the etiology is complex and not fully understood.[5] There are many contributing factors associated with obesity, some of which have been researched a great deal. For example, diet and exercise have been studied extensively regarding how they contribute to obesity, and much has been discovered regarding their role in the treatment and prevention of obesity. On the other hand, many other contributing factors have not been researched sufficiently for meaningful conclusions to be made.[2] One of these factors is emotional health.

Although it is widely assumed that mental problems are associated with obesity and may even be the cause for obesity, evidence for these conclusions is generally derived from case reports and not large studies.[6]

Depression is probably the most commonly studied psychological component that may contribute to obesity[6]. Although multiple studies have investigated the correlation between depression and obesity, a consistent association has not been established.[2]

Several cross-sectional studies have demonstrated a positive correlation between depression and obesity,[2,7-14] while research by Hach et al.[15] has demonstrated no such association. Some prospective studies have shown that depression in childhood predicts weight gain and obesity in adulthood, especially in females.[3,16-18] However, others have failed to show similar results.[19]

In addition to the studies that have investigated depression and obesity, several studies have been conducted to determine the relationship between emotional health and obesity. Although a positive association has been established in clinical settings epidemiologic studies have revealed weak and inconsistent findings.[20]

Does negative emotional health lead to weight gain and obesity? The evidence appears divided. Although cross-sectional and clinical research is indicative of a significant relationship, epidemiologic studies are less supportive. Moreover, prospective investigations which have evaluated the connection between emotional health and weight gain have displayed a number of weaknesses. For example, nearly all prospective studies to date have utilized BMI to index obesity, whereas the current study utilized the Bod Pod to measure body fat percentage. In addition, adjustments for differences in physical activity and energy intake have not been employed in previous investigations, but were controlled in this study. Furthermore, other studies have generally investigated subjects with severe mental illnesses, whereas the current study investigated women within the parameters of normal emotional health. Finally, little is known about the link between emotional health and weight gain in middle-aged females. Hence, the focus on this group in the present study adds much needed insight.

The purpose of this study was to research prospectively the extent to which measured emotional health affects the risk of gains in body fat percentage and body weight in middle-age women. Another objective was to determine the influence of potentially confounding factors on the relationship between depression and weight and body fat gains.

Methods

Study Population

A total of 275 female subjects participated in the baseline phase of the study. In order to be enrolled in the study, subjects were required to be between the ages of 35 and 45 years, have a BMI <30 kg/m², and be a nonsmoker. In addition, at baseline, subjects were required to be premenopausal, not pregnant, and not planning to become pregnant during the duration of the study. After almost two years, 256 women participated in the second phase of the cohort study.

Emotional Health

Emotional health was assessed utilizing the General Well-Being (GWB) Schedule. The GWB schedule is a self-report instrument which contains 18 items that contribute to the total score. The instrument measures several components of emotional health including health worry, energy level, satisfying-interesting life, depressed-cheerful mood, emotional-behavioral control, and relaxed versus tense-anxious.[21] Collectively the scale offers an indication of emotional well-being and distress or depression.[22]

The GWB schedule was developed by the National Center for Health Statistics (NCHS) after pre-testing 373 adults, and was later administered as part of the Health and

Nutrition Examination Survey from 1971-1975. Since then, the GWB schedule has been used in several large-scale studies,[21] and has also been translated into many different languages for use in other countries.[22-24]

Validity of the GWB schedule was investigated by Fazio utilizing 195 college students.[21] The study compared the GWB schedule with several other self-report scales, and also compared each scale against interviewer ratings of current depression. The results of the study demonstrated that the GWB schedule "was clearly better than most of the other measures in its strength of relationship with the interviewer rating of depression."[21] In addition, of the 28 scales and subscales investigated in the study, the GWB schedule was found to be "the single most useful instrument in measuring depression."[21] Therefore, the GWB schedule was selected as the measurement tool for emotional health and depression in the current study. Each subject completed the GWB schedule at baseline and follow-up.

Body Weight

Body weight was measured utilizing an electronic scale (Tanita Corp, Japan) that was calibrated daily using known weights. Readings from the scale were given via a computer interface to the nearest 0.01 lb (0.005 kg). Each subject was measured after using the restroom, and while wearing only a bathing suit provided by the university. In addition, subjects were asked not to eat during the four hours prior to their scheduled weighing. Subjects were weighed at both the first and second appointments so that the average of the two measurements could be used to index body weight.

Body Fat

Reliability of the Bod Pod (Life Measurements Instruments, Concord, CA) was assessed utilizing 100 subjects from the study cohort. A test-retest protocol was employed with each subject repositioned between tests, and an intra-class correlation of 0.999 ($p < .001$) was found between the two Bod Pod tests.[25]

Validity of the Bod Pod was examined with concurrent testing using Dual Energy X-ray Absorptiometry (Hologic 4500W, Bedford, Massachusetts). A total of 100 subjects from the cohort also participated in this validational study. Pearson correlation between the two measures of body fat percentage was 0.94 ($p < .001$), and the intra-class correlation was 0.97 ($p < .001$).

Ballard, Fafara, and Vukovich also demonstrated the validity and reliability of the Bod Pod utilizing 47 females.[26] All subjects were assessed for body composition by both the DEXA and the Bod Pod machines. The results of the study revealed that there were no significant differences between the DEXA mean and the Bod Pod mean.

Further evidence of Bod Pod reliability was demonstrated in a study of 980 subjects by Noreen and Lemon.[27] Each participant was assessed two times for body composition in the Bod Pod. Statistical analyses of the testing revealed no significant differences between the first and second tests.

All subjects in the present study reported to the Human Performance Research Center (HPRC) to be assessed for their individual body fat percentage. Subjects were provided with a bathing suit and swim cap to wear during testing, and they were also instructed not to eat or exercise four hours prior to testing. The Bod Pod was calibrated each day with a known volume cylinder. Testing was conducted and repeated until two of the results were within one percentage point of each other. The results of the two tests were then averaged for a final index of body fat percentage.

Physical Activity

Physical activity was objectively assessed utilizing MTI (formerly known as CSA) accelerometers (MTI, Shalimar, FL). These activity monitors have demonstrated high-level validity and reliability for measuring physical activity. Welk, Schaben, and Morrow examined the reliability of four different accelerometer types.[28] Each subject in the study underwent three trials in which a series of 5-minute bouts of walking were followed by a 1-minute standing rest period. Statistical analyses demonstrated that MTI/CSA had the least amount of variability and the highest overall reliability of the differing accelerometer types.

At baseline, a pilot study of 15 subjects was conducted to further investigate the validity and reliability of the MTI/CSA monitors. Results of the pilot study showed that the MTI/CSA monitors could detect differences in walking and jogging speeds of as little as 0.1 mph and differences in grades as small as 1%. In total, subjects were tested while performing 17 different activities. Two to four days later, subjects participated in the same 17 activities. Total activity counts for the first set of activities were compared to the same activities performed the second time, and the test-retest intraclass correlation was 0.98 ($p < 0.001$), showing high reliability.

All subjects were instructed to position the MTI/CSA monitor over their left hip, in line with the middle of the lateral aspect of the leg, around the waist. The monitors were worn at all times for seven consecutive days except when bathing or participating in water activities.

All of the MTI/CSA monitors used in the current study were programmed to sum physical activity into 1-minute epochs. These 1-minute intervals were then collapsed into 10-minute epochs. Across the seven days, subjects had 1008 total epochs. The sum of all activity counts across the 1008 epochs was used to index total physical activity.

Energy Intake

The assessment of energy intake was performed using weighed 7-day diet records. This method is considered one of the most precise measurements of energy intake and nutrient consumption in the field.[29]

Each subject in the current study was instructed on how to weigh all food and drink that was ingested during the week using an Ohaus 2000 electronic scale (Ohaus, Florham Park, NJ). Subjects were also instructed to record on diet logs everything they ate or drank during the 7-day period. If the total amount of calories consumed by the subjects was less than 130% of estimated resting metabolic rate, they were asked to redo the dietary log. Subjects who would not comply were dropped from the study.

All dietary logs were analyzed by a Registered Dietitian utilizing the ESHA research software program, version 7.4 (Salem, OR).

Procedure

Baseline data were collected during two appointments scheduled eight days apart. All appointments for subjects took place in the HRPC at the university. At baseline, risks and benefits of the study were explained and subjects were assured that all data collected by the researchers would remain confidential. In addition, each subject signed an informed consent that had been approved by the university IRB.

During the first appointment, subjects were instructed on proper usage of the MTI/CSA activity monitors, and how to correctly weigh and record their dietary intake. Subjects were also assessed during this time for height, weight, and body fat percentage using the Bod Pod. Furthermore, subjects completed the GWB schedule.

Following the first appointment, subjects were contacted every other day to ensure compliance with the study parameters. During the week, subjects weighed and recorded dietary intake and wore the MTI/CSA monitors at all times except when bathing or participating in water sports. After eight days, subjects returned to the Human Performance Research Center to turn in their dietary logs and MTI/CSA monitors for analysis. Subjects were also weighed at this time in the same manner as described previously.

Approximately 20 months after the baseline assessments, subjects were invited to come in for a follow-up evaluation. During the follow-up appointments, the same measurements that were taken at baseline were repeated. At both time periods, after the data was collected and analyzed, the results were sent to each of the subjects along with a $25 gift certificate.

Statistical Analysis

All statistical analyses were computed using SAS software, version 9.1 (SAS Institute, Inc., Cary, NC). Descriptive data, including means and standard deviations, were generated for each variable. Changes in body weight and body fat percentage were calculated by subtracting baseline means from follow-up means. Weight gain was defined as increases of 2 kg or more over the 20-month study period, and gain in body fat percentage was considered increases of 2 percentage points or more.

As established by the National Center for Health Statistics, scores of 55 and below on the GWB schedule were used to indicate significant emotional distress or depression, and women with GWB values above 55 were categorized as nondepressed. Similarly, GWB scores greater than 80 were used to index positive emotional health and scores of 80 and below reflected women with LTP emotional health.

Risk of weight gain and gains in body fat percentage in depressed women compared to their counterparts was determined by comparing the incidence rates of the two groups. Similarly, risk of gains in women with LTP emotional health was compared to those with perceived positive well-being. Statistical significance was determined using 95% confidence intervals. The relative risk calculations were adjusted for differences in potential confounding factors, including age, time between the assessments, baseline physical activity, baseline energy intake, baseline body weight, and changes in physical activity and energy intake over the 20 months, treated individually and in combination, using a modified Poisson regression approach with robust error variance, as explained by Zou.[30]

Results

Of the 275 subjects tested at baseline, 256 (93%) were assessed at follow-up and included in the analysis. Average time between the assessments was 590.6 days ±65.1 days. Reasons for dropping out of the study included loss of interest, divorce, auto accident, pregnancy, noncompliance, and moving from the area. The vast majority of the participants in this study were Caucasian (95%), educated (90% with some college), and married.

Changes in key variables over the study period are displayed in Table 1. Throughout the 20-month study, the average body weight, body fat %, and BMI of the subjects increased significantly. Conversely, the average daily physical activity and the mean daily energy intake of the subjects decreased significantly.

As shown in Table 2, of the 256 subjects included in the analysis, 171 (66.8%) demonstrated LTP emotional health, or a GWB score of 80 or below. On the other hand, 85 of the subjects (33.2%) demonstrated positive emotional health**,** or a GWB score above 80. The mean GWB score for all subjects was 73.2 (SD=14.8). Almost 40% of the subjects (37.4%) with LTP emotional health at baseline gained weight during the study period, whereas only 23.5% of the participants with positive emotional health at baseline gained weight over the 20 months.

Table 3 shows the risk of weight gain for women with LTP emotional health compared to those with positive emotional health. When none of the potential confounding variables were controlled, women with LTP emotional health had 59% greater risk of weight gain over the 20 months than their counterparts with positive emotional health (RR 1.59, 95% CI = 1.04-2.44). However, Table 4 demonstrates that women with LTP emotional health were at no greater risk of gains in body fat percentage than women with positive emotional health (RR = 0.96, 95% CI = 0.70-1.33).

Several variables were controlled individually in the weight gain analysis, however none of them caused the risk of weight gain to become statistically insignificant (Table 3). Specifically, after adjusting separately for differences in baseline age, physical activity, energy intake, body weight, changes in physical activity, changes in energy intake, and time between assessments, no meaningful influence was revealed on the risk of weight gain. However, when all of the potential confounders were controlled in combination, risk of weight gain among women with LTP emotional health was weakened (RR = 1.43, 95% CI = 0.93-2.21).

The same variables that were controlled in the weight gain analysis were also controlled in the body fat % gain analysis. In like manner, following the adjustment of the variables, none were found to significantly influence the risk of gaining body fat.

Comparisons between women with positive emotional health and LTP emotional health revealed that the two groups did not differ significantly in age, education, or marital status. Furthermore, there were no differences between the means of the two groups in changes in physical activity and energy intake over the 20 months. However, baseline physical activity levels differed significantly between the groups. Specifically, women with positive emotional health had mean activity counts of 2946.7 (SD=960.2) [activity counts/1000], whereas women with LTP emotional health had mean activity counts of 2696.5 (SD=773.0) ($F = 5.04$, $p = 0.03$).

Women who were depressed at baseline ($n = 36$) were at no greater risk of weight gain or gains in body fat percentage than women ($n = 220$) who were not depressed at baseline (RR = 1.02, 95% CI = 0.62-1.68). After adjusting for potentially confounding factors, such as baseline age, physical activity, energy intake, body weight, changes in physical activity, changes in energy intake, and time between assessments, risk of weight gain or body fat gain among the depressed compared to those not depressed remained statistically insignificant.

Discussion

Subjects in the current study were consistent with national trends in that over time women tend to gain weight and body fat[1]. On average, there were significant gains in body weight and body fat across the study. Approximately one-third of the women gained 2 kg or more over the 20-month investigation. However, not all subjects gained weight at the same rate, and 38.3% of the subjects actually lost weight.

Findings from the present study demonstrated that women with LTP emotional health were at significantly greater risk of gaining weight than middle-aged women with positive emotional health. Furthermore, this risk was independent of age, baseline body weight, baseline physical activity, changes in physical activity, baseline energy intake, changes in energy intake, and time between assessments. In other words, women with LTP emotional health were at greater risk of gaining weight regardless of their age, their initial body weight, how much physical activity they participated in, and how many calories they consumed.

Numerous studies have investigated the association between emotional health and weight gain, with the vast majority focusing on the negative effects of depression. Most have concluded that depression increases the risk of weight gain.[3,16-18,20] However, findings from the current study are not totally consistent with such conclusions. Women in the present study who were depressed were at no greater risk of weight gain than their nondepressed counterparts. However when depressed women were categorized with all women who had LTP emotional health, risk of weight gain was substantial. In fact, women with LTP emotional health had 59% greater risk of weight gain than women with positive emotional health.

Although women in the current study with LTP emotional health were at greater risk of weight gain across the study, post-hoc analysis revealed that this group was at no greater risk for gains in body fat %. Even after age, baseline physical activity, baseline body weight, changes in physical activity, baseline energy intake, changes in energy intake, and time between assessments were controlled, women with LTP emotional health were at no greater risk of gains in body fat percentage than women with positive emotional health. Perhaps LTP emotional health did not influence risk of gains in body fat over time because there is greater measurement error associated with assessment of body fat than the assessment of body weight.

The present study was not without limitations. First, there was little ethnic diversity among the subjects, which limits the generalizability of the study. Next, the duration of the study was only 20 months. A longer study would have allowed subjects with differing states of emotional health to separate more in their body composition through continued weight gain and weight loss. Finally, anti-depressant medication usage was not monitored in the study.

Because of the prospective cohort design of the present study, cause-and-effect conclusions are not warranted. However, if a causal relationship were assumed, then the risk of weight gain among middle-aged women may be reduced by improving their emotional health. Previous research has concluded that energy intake and energy expenditure are the key factors in weight management. Perhaps greater emphasis needs to be placed on the emotional well-being of women trying to lose weight.

Research clearly indicates that emotional well-being affects many behaviors. In the present study, post-hoc analysis showed that as emotional health improved, objectively measured physical activity increased ($r = 0.20$, $p = 0.0015$). Other research examining the relationship between physical activity and depression has demonstrated that more physical activity among adults was associated with less depression.[31] In 2006, Masheb and Grilo[32] correlated emotional overeating with depression, and conclusions formulated by Polivy and Herman stated that negative moods affect dieting.[33] All of the aforementioned behaviors associated with negative emotional health may contribute to weight gain and may have been factors affecting outcomes of the current study.

Statistical adjustment for differences in objectively measured physical activity had no influence on risk of weight gain over the study period. Likewise, controlling for energy intake had little impact on the relationship. However, when all of the potential confounding factors were controlled simultaneously, risk of weight gain was weakened and the association was no longer statistically significant. Apparently, LTP emotional health increases risk of weight gain in women through several factors acting together. Although many factors were measured in the present study, there are always other variables which may contribute to weight gain that were not assessed in the current investigation such as medication usage. Undoubtedly, more research regarding the role of emotional health in physical activity, eating, and related behaviors is warranted.

Conclusion

In conclusion, emotional health plays a substantial role in the risk of weight gain among middle-aged women as evidenced by the current study. Women with LTP emotional health were found to be at much greater risk of weight gain than women with positive emotional health. This risk was independent of the subject's age, initial body weight, energy intake, and physical activity levels. These findings suggest that although caloric balance is crucial when attempting to manage weight, emotional health may directly or indirectly affect caloric balance and therefore play a significant role in weight gain over time.

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Table 1-Changes in key variables over the 20-month study period

Variable	Baseline Mean (SD)		20-month Mean (SD)		Mean Difference (SD)		F value	P value
Body Weight (kg)	65.35	(10.2)	66.10	(10.7)	0.75	(3.7)	10.6	0.0013
Body Weight (lbs)	143.77	(22.4)	145.42	(23.6)	1.66	(8.2)	10.6	0.0013
Body Fat %	31.12	(7.0)	32.19	(7.4)	1.07	(3.7)	21.0	<0.0001
BMI	23.58	(3.3)	23.85	(3.5)	0.27	(1.4)	10.1	0.0017
Energy Intake (kcal)	2045.22	(309.5)	1951.74	(316.2)	-91.54	(303.6)	23.3	<0.0001
Physical Activity[a]	2779.6	(846.2)	2620.1	(932.9)	-1595.2	(756.4)	11.4	0.0009

Note: F and P values are based on the mean difference score.

[a]Physical Activity=Activity counts/1000

Table 2-Incidence of weight gain among women with positive and LTP emotional health

Variable	Weight Gain (≥2 kg)		No Weight Gain		Total Number	Total Row %
	N	Row %	N	Row %		
LTP[a] Emotional Health	64	37.4%	107	62.6%	171	66.8%
Positive Emotional Health	20	23.5%	65	76.4%	85	33.2%
Total	84		172		256	100%

Subjects who gained ≥2 kg of body weight over the 20-month study period were in the Weight Gain Group, whereas those who gained < 2 kg were in the No Weight Gain Group.
[a]LTP = Less Than Positive emotional health

Table 3-Risk of weight gain with and without adjustment for potential confounders

Outcome: Weight Gain ≥ 2 kg		
Risk Factor: LTP[a] emotional health	Relative Risk	(95% CI)
Variable Adjusted for:		
None	1.59	1.04-2.44
Baseline Age	1.60	1.04-2.47
Baseline Physical Activity	1.54	1.00-2.38
Baseline Energy Intake	1.59	1.04-2.44
Baseline Body Weight	1.56	1.01-2.41
Change in Physical Activity	1.59	1.03-2.45
Change in Energy Intake	1.65	1.08-2.51
Time Between Assessments	1.55	1.01-2.38
All of the above	1.43	0.93-2.21

[a]LTP = Less Than Positive emotional health

Relative Risk values on the same row as a potential confounding variable, such as Baseline Age, show the risk of gaining ≥2 kg after adjusting for differences in the potential confounder.

Table 4-Risk of body fat gain with and without adjustment for potential confounders

Outcome: Body Fat % Gain ≥ 2%		
Risk Factor:		
LTP[a] emotional health	Relative Risk	(95% CI)
Adjusted for:		
None	0.96	0.70-1.33
Baseline Age	0.98	0.71-1.35
Baseline Physical Activity	0.96	0.70-1.33
Baseline Energy Intake	0.97	0.70-1.34
Baseline Body Fat%	1.03	0.75-1.42
Change in Physical Activity	0.97	0.70-1.33
Change in Energy Intake	1.00	0.73-1.37
Time Between Assessments	0.95	0.69-1.32
All Variables	1.00	0.72-1.39

[a]LTP = Less Than Positive emotional health

Relative Risk values on the same row as a potential confounding variable, such as Baseline Age, show the risk of gaining ≥2% body fat after adjusting for differences in the potential confounder.

Appendix A

Prospectus

Chapter 1

Introduction

It is well established in the literature that the prevalence of obesity and overweight have become major health problems in the United States (Onyike, Crum, Lee, Lyketsos, & Eaton, 2003). In addition, obesity is one of the most costly health problems in the country (Kress, Peterson, & Hartzell, 2006). Both overweight and obesity are linked to several chronic diseases including, hypertension, hypercholesterolemia, type 2 diabetes, heart disease, osteoarthritis, and gallbladder disease (Hasler, Pine, Kleinbaum, Gamma, Luckenbaugh, & Ajdacic, et al., 2005). In 1998, it was stated that “obesity will probably replace cigarette smoking as the major killer of Americans in the next century” (Grundy, 1998, p. 569S).

The treatment and prevention of obesity has proven to be very difficult, partly because the etiology is complex and not fully understood (Gustafson & Sarwer, 2004). There are many contributing factors associated with obesity, some of which have been researched a great deal. For example, diet and exercise have been studied extensively regarding how they contribute to obesity, and much has been discovered regarding their role in the treatment and prevention of obesity. On the other hand, many other contributing factors have not been researched sufficiently for meaningful conclusions to be made. One of these factors is depression.

In addition to obesity, depression is also one of the most costly and prevalent health problems facing Americans (Kress et al., 2006). Evidence indicates that 10% of the population suffers from depression annually (Kress et al., 2006). Multiple studies have investigated the association between depression and obesity, however, a consistent association has not been established (Kress et al., 2006).

Several cross-sectional studies have demonstrated a positive correlation between depression and obesity (Gil, Radziłłowicz, Zdrojewski, Pakalska-Korcala, Chwojnicki, & Piwoński, et al., 2006; Hopkinson & Bland, 1982; Istvan, Zavela, & Weidner, 1992; Johnston, Johnson, McLeod, & Johnston, 2004; Kress et al., 2006; Lacoursiere, Baksh, Bloebaum, & Varner, 2006; Onyike, Crum, Lee, Lyketsos, & Eaton, 2003; Simon, Von Korff, Saunders, Miglioretti, Crane, & van Belle, et al., 2006; Wadden, Butryn, Sarwer, Fabricatore, Crerand, & Lipschutz, et al., 2006), while research by Hach, Ruhl, Klotsche, Klose, and Jacobi (2006) has demonstrated no such association. Some prospective studies have shown that depression in childhood predicts weight gain and obesity in adulthood, especially in females (Anderson, Cohen, Naumova, & Must, 2006; Hasler et al., 2005; Pine, Goldstein, Wolk, & Weissman, 2001; Richardson, Davis, Poulton, McCauley, Moffitt, & Caspi, et al., 2003). However, others have failed to show similar results (Roberts, Deleger, Strawbridge, & Kaplan, 2003).

Does depression lead to body fat gain and obesity? The evidence appears divided. Although cross-sectional research is indicative of a strong relationship, prospective studies are somewhat less supportive. Moreover, prospective investigations which have evaluated the connection between depression and weight gain have displayed a number of weaknesses. For example, nearly all prospective studies to date have utilized BMI to index obesity, whereas the proposed study will measure body fat percentage using the

Bod Pod. In addition, adjustments for differences in physical activity and energy intake have not been employed in previous investigations, but will be controlled in the current study. Finally, little is known about the link between depression and weight gain in middle-aged females. Hence, the present study will focus on this high risk group.

The current study should provide valuable information regarding the link between depression and obesity in middle-aged females. Additional insights into the depression-obesity relationship may encourage the treatment of depression to enhance weight management (Hasler et al., 2005), and increase understanding of an additional factor that contributes to obesity.

Statement of the Problem

The proposed study will seek to research prospectively the extent to which measured depression affects the risk of gains in body fat percentage and body weight, utilizing data from the Brigham Young University Lifestyle Study. A secondary objective will be to determine the influence of potentially confounding factors on the relationship between depression and weight and body fat gains.

Research Questions

1. To what extent does depression influence risk of weight gain in middle-aged women over time?
2. To what extent does depression influence risk of gains in body fat percentage in middle-aged women over time?

3. To what extent do potential confounding factors, such as physical activity and energy intake, considered individually and in combination, affect the relationship between depression and weight gain?

Assumptions

For the purpose of this study it will be assumed that

1. The subjects were accurate and honest when answering questions addressed in the General Well-Being Schedule.
2. All subjects arrived for Bod Pod measurements without eating or exercising 3 hours prior to their respective appointment times.
3. All subjects correctly utilized and wore the accelerometers for seven consecutive days.
4. All subjects correctly weighed and recorded their food intake for seven consecutive days.

Limitations

1. The study is not a randomized controlled trial, therefore cause and effect conclusions cannot be made.
2. The study will utilize self-reported depressive symptoms rather than interviews by trained professionals.

Delimitations

The study utilized middle-aged female subjects living in Utah County, Utah. In order to participate in the study, each subject had to have a BMI score below 30 kg/m^2 at baseline. Depression among the subjects was measured utilizing the General Well-Being

Schedule, body fat percentage was ascertained via the Bod Pod, and weight was assessed using an electronic scale. Duration of the prospective study was approximately 2 years.

Operational Definitions

Obesity—an accumulation of fat which causes excess weight. In the present study, obesity will be defined as a body fat percentage greater than 35%.

Depression—an emotional condition characterized by dejection and withdrawal, where sadness is prolonged without any objective reason. Depression is also a physiological condition wherein abnormalities in the neurotransmitters within the brain exist. For the current study, depression will be defined as scores on the General Well-Being Schedule less than 56. Relative depression will be defined as scores that place an individual in the lowest quartile of the sample of the investigation.

Bod Pod—A measurement tool used to ascertain body fat percentage of subjects by utilizing air displacement plythesmography.

Chapter 2

Review of Literature

The current literature review will investigate studies that specifically discuss depression and its affect on weight gain, body fat gain, and overweight/obesity status. This review will be divided into categories based on study design, and age demographics of the subjects. The categories in this review will include, prospective childhood data, prospective adult data, cross-sectional data, case control studies, and review articles.

Prospective Childhood Data

Anderson et al. (2006) investigated childhood to adulthood weight change and its association with depression and anxiety disorders in a study consisting of 403 females and 417 males who were between the ages of 9 and 18 at baseline. Subjects for this study underwent structured diagnostic interviews four different times during the 20-year study to assess for depression and anxiety disorders. BMI was calculated at the interviews by self-reported weight and height, and BMIz scores were calculated when the subjects were between the ages of 9 and 20 for greater accuracy.

Statistical analyses were performed to ascertain the differences in BMI and BMIz scores with the onset of anxiety or depression. A history of depression and anxiety disorders was associated with greater yearly gains in BMIz scores in females compared with their non-depressed counterparts. However, in males, depression predicted lower BMIz scores compared to males who were not depressed. In addition, early onset depression in females was associated with higher BMI values than depression onset at older ages. Anderson et al. (2006) stated that their results were, “broadly consistent with other prospective studies in finding that psychological distress, especially when present in childhood, predicts higher weight (p. 289), " at least in females.

Tanofsky-Kraff, Cohen, Yanovski, Cox, Theim, and Keil, et al. (2006) administered a prospective study for 146 children between the ages of 6-12 to investigate psychological predictors of body fat gain. The subjects included in this study were considered "at risk" for adult obesity because they were overweight themselves, or had one or more parents who were overweight. Each subject completed several questionnaires, including the Children's Depression Inventory, to assess depressive symptoms, and underwent dual-energy x-ray absorptiometry (DXA) scans to determine body fat mass at baseline. Each of the subjects was followed annually receiving DXA scans for an average of 4.2 years.

The results of several statistical analyses showed that binge eating and dieting were both significant predictors of increases in body fat mass, but depressive symptoms were not. Although depressive symptoms were not predictive of body fat gain in this study, the researchers reported that very few of the subjects met the criteria for clinical depression, and many subjects had not undergone puberty when depression often manifested itself.

Further research by Hasler et al. (2005) also investigated the association between depressive symptoms during childhood and adult obesity utilizing data collected in the Zurich Cohort Study. Subjects for this study were between the ages of 19 and 40, and participated in six semi-structured diagnostic interviews over a 20-year period to assess depressive symptoms, medical conditions, and other health habits. BMI was determined for each subject by self-reported height and weight. At the baseline interview, subjects were assessed for past (childhood) depression and the age for the onset of depression.

Statistical analyses of the data demonstrated that women with a history of childhood depression had higher BMI values than women without childhood depression. After controlling for covariates in men, there was also a positive association between childhood depressive symptoms and increases in BMI with age. These results again demonstrated the significant association between childhood depression and adult weight gain and obesity, especially in females.

Richardson et al. (2003) utilized data from a longitudinal study of a birth cohort of children born in New Zealand to evaluate the association between adolescent depression and adult obesity. Subjects in this study underwent regular diagnostic mental health interviews and BMI measurements throughout childhood and adolescence. Logistic regression analyses were performed to determine the association between major depression in adolescence and the risk for obesity at age 26. The results of the analysis demonstrated that girls who were depressed during late adolescence were at a greater than two-fold risk for obesity during adulthood than girls who were not depressed. The same association was not observed, however, for late adolescent boys, or for early adolescent boys or girls.

A final study by Pine et al. (2000) investigated the association between childhood depression and adult BMI with 177 subjects between the ages of 6-17 for 10-15 years. Ninety of the subjects were selected when they presented at a psychiatric clinic for treatment, and each met the diagnostic criteria for major depression. The other 87 subjects had no current or past psychiatric history and were recruited from local schools. Each subject underwent a standardized psychiatric interview to assess psychiatric status at baseline and at follow-up. The results of the statistical analyses demonstrated that subjects with childhood depression had larger BMI values as adults than subjects without childhood depression. Other analyses revealed that subjects with childhood depression had two times the risk of overweight status than their non depressed counterparts. This again adds to the body of evidence that “depression during childhood is positively associated with BMI during adulthood” (Pine et al., 2000, p. 1053).

Of the studies reviewed in this section, one showed that depression in childhood was not a significant predictor of body fat gain. However, studies conducted by Anderson et al. (2006), Hasler et al (2005), Pine et al. (2000), and Richardson et al. (2003), all demonstrated that depression in childhood was positively associated with BMI scores in adulthood. Furthermore, these associations were generally stronger for females than they were for males. Therefore, a significant amount of evidence suggests that depression, especially in females, in childhood or adolescence may predict future weight gain, and possibly overweight or obesity in adulthood.

Prospective Adult Data

Very few studies have been conducted investigating the affects of depression on weight gain over time in adults. Although few studies exist, those presented in this section do offer some evidence of a correlation between the two variables of interest, depression and weight gain over time.

Hasler, Pine, Gamma, Milos, Ajdacic, and Eich, et al. (2004) tested the hypothesis that major depression would predict an increase in long-term variability in body weight among young adults. To test this hypothesis, the researchers utilized a stratified sample of 479 subjects at the age of 19 from the Zurich Cohort Study. The subjects participated in six different screening interviews to assess several somatic diseases and psychiatric disturbances over a 20-year period. Major depression was diagnosed based upon the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria. Self-reported body weight and height were provided at each interview and converted into BMI. Body Weight Variability (BWV) was then calculated on the basis of the BMI values over time.

Several cross-sectional and longitudinal statistical analyses were performed to determine the association between major depression and BWV. These analyses showed a positive association between major depression and BWV, but no association with BMI level or BMI trend. In addition, there was a dose-response relationship between depression severity and magnitude of BMV, and an association between major depression and a later increase in body weight change. The researchers reported that the results from their study demonstrated that depression is an important risk factor for increased BWV.

Another publication by Hasler et al. (2004) utilized data from the same Zurich cohort study, but investigated the association between being overweight and a range of psychiatric conditions, including depression. The results of this analysis showed depression was positively associated with increased weight gain and being overweight.

Roberts et al. (2003) investigated the association between obesity and depression using a two-wave 5-year observational study. A total of 2123 subjects who were over the age of 50 participated in this study. Subjects provided a self-reported body weight and height, which was converted to BMI, and depression was measured using a set of 12 items or symptom queries entitled DSM-12D. Statistical analyses were used to test the differences in the percentage of obese subjects with depression, and to assess the association between obesity at baseline and depression at five years, and depression at baseline and obesity at five years.

When data from baseline and follow-up was examined cross-sectionally, there was a significant association between depression and obesity. Further examination of the prospective data showed that subjects who were obese at baseline had an increased risk of becoming depressed after the 5-year follow-up period than subjects who were not obese. Additional analyses demonstrated that subjects who were depressed at baseline had no greater risk of being obese at follow-up than those who were not depressed. The researchers concluded from their study that obesity was predictive of subsequent depression, but depression was not predictive of subsequent obesity for their study sample.

For the research presented in this section, there seems to be a positive association between depression and weight gain over time, and an association between depression and body weight variability over time in adults between the ages of 19 to 40 years. For adults over 50, there seems to be no association between depression and weight gain, although this was only for one study. The lack of sufficient research in this area makes it difficult to reach conclusions regarding the true association between depression and weight gain over time in older adults.

Cross-Sectional Data

Several cross-sectional studies have been performed to investigate the association between depression and overweight and obesity. Although these studies can be useful for finding associations, they are not beneficial for determining causality. Nevertheless, the research presented in this section helps to demonstrate the associations that have been found between depression and overweight and obesity, using several different populations.

The association between obesity and psychiatric disorders in U.S. adults was explored cross-sectionally by Simon et al. (2006). A total of 9125 subjects self-reported their height and weight and completed an interview where several mental disorders were assessed. The results of their study shows that “obesity [is] associated with significant increases in lifetime diagnosis of major depression (p. 828),” among other disorders.

Additional research by LaCoursiere et al. (2006) investigated the correlation between maternal BMI and postpartum depressive symptoms. Data for this study were obtained from the 2000-2001 Pregnancy Risk Assessment Monitoring System in Utah. Subjects were stratified by pre-pregnancy BMI, and after controlling for marital status and income, the lowest rate of self-reported postpartum depressive symptoms was found in the women with a normal BMI (19.8-25.9). Women who were overweight or obese had a two-fold increase in the amount of self-reported depressive symptoms compared to their normal weight counterparts. These results suggest a possible positive correlation between pre-pregnancy BMI and postpartum depression.

Further research by Gil et al. (2006) investigated the relationship between depressive symptoms and the metabolic syndrome. There were 477 female and 318 male subjects between the ages of 50 and 60 years who participated in this study. Each subject was examined for the metabolic syndrome, and it was determined that 31% of the women and 33% of the men met the criteria for this diagnosis. Depression was assessed using Beck's Depression Inventory, and symptoms of depression were found in 42% of females and 28% of males. Statistical analyses revealed that the metabolic syndrome was more common in subjects with depressive symptoms than those without depressive symptoms. In addition, visceral obesity was also more common in males with depressive symptoms than in those without depressive symptoms.

A study comparing the psychosocial status of women with class III obesity, and women with class I-II obesity was conducted by Wadden et al. (2006). Subjects participating in this study completed the Beck Depression Inventory-II and the Weight and Lifestyle Inventory. When compared to women with class I-II obesity, the women with class III obesity reported significantly more symptoms of depression. In addition, the women with class III obesity reported significantly greater amounts of psychiatric complications than the women with class I-II obesity.

Waist circumference (WC) and its association with depressive disorders was researched by Hach et al. (2006) using a representative sample of 4181 subjects from the German population between the ages of 18 to 65 years. Each subject in this study completed a self-report questionnaire and a standardized computer-assisted medical interview. In addition, each subject was assessed for anthropometric measurements and underwent a screening for mental disorders. Multiple logistic regression analyses were performed to determine associations between WC and mental disorders. When depression and WC were analyzed together, there was no significant association found between the two variables. Although several other cross-sectional studies have demonstrated an association between abdominal obesity and depression, this study failed to show such results.

An additional correlational study by Johnston et al. (2004) investigated the relationship of BMI to depressive symptoms utilizing data from the 1995 Nova Scotia Health Survey. A total of 2431 subjects over the age of 18 years completed the Center for Epidemiological Studies-Depression Scale (CES-D), which was used to assess depressive symptoms in the previous week. A public health nurse weighed and measured the height of each subject and then BMI was calculated from those measures.

When the data were analyzed statistically, obese subjects were significantly more likely to be at risk for depression than those who were not obese. Further analyses that controlled for education and income showed that subjects who were obese were 41% more likely to be depressed than their non-obese counterparts.

Kress et al. (2006) researched the association between obesity and depressive symptoms among a more specific population of military active duty service personnel. There were a total of 10,040 subjects that completed the U.S. Department of Defense Survey of Health Related Behaviors for this study. As part of the survey, subjects reported height and weight, which was converted into BMI, and they responded to questions from the Burnam Screen regarding depression.

Statistical analyses revealed that obesity was associated with a three-fold increase in risk of depressive symptoms among women when compared with normal weight women. In addition, men who were categorized as underweight or obese had an increase in the risk of depressive symptoms when compared with normal weight men.

Onyike et al. (2003) investigated the relationship between obesity and depression using data from the Third National Health and Nutrition Examination Survey (NHANES III). A total of 39,695 subjects participated in NHANES III, but this particular study only utilized data from 8410 subjects between the ages of 15 and 39 years. Each of the 8410 subjects underwent a Diagnostic Interview Schedule for determination of depressive and bipolar disorders, and each was assessed for body weight and height. Statistical analyses were used to compare the risks of depression in obese and normal weight subjects. The results revealed that the prevalence of past month depression was higher for female-obese subjects than for their normal weight counterparts. In addition, as levels of obesity increased in women, so did the prevalence of depression. For individuals with a BMI > 40, there was an association found with depression for both the women and the men. Furthermore, there was an association between women with a BMI > 40 and lifetime depression. Onyike (2003) stated that their findings suggested that, "obesity is associated with depression mainly among persons with severe obesity (p. 1139)."

Additional cross-sectional research by Istvan et al. (1992) examined the relationship between BMI, smoking status, and depression utilizing data from the First National Health and Nutrition Examination Survey (NHANES I). Data for NHANES I were collected from approximately 32,000 subjects between 1971 and 1975. However, the population for the current analysis consisted of adults between the ages of 25 and 74, who participated in more extensive testing during 1974 and 1975. Depressive symptoms were measured for each subject using the twenty-item Center for Epidemiologic Studies Depression scale (CES-D). In addition, each subject was assessed for body weight and height, which was converted into BMI. Statistical analyses on the data demonstrated that depressive symptoms were weakly but significantly associated with BMI among women, but not among men.

In a study conducted by Hopkinson and Bland (1982), 73 grossly obese women were evaluated for depressive symptoms to determine the presence of an association between obesity and depression. Subjects for this study were at least 100 pounds above or double their ideal weight, and were candidates for intestinal by-pass surgery. Each of the subjects was interviewed by the primary researcher for presence and or history of depressive symptoms and diagnoses were made accordingly. It was determined that 14 of the 73 subjects met the diagnostic criteria for primary depression, and 57 of the subjects reported periodic depressed moods. The researchers concluded that the expectancy for primary depression within their study population was “ten times that found in the general female population” (Hopkinson and Bland, 1982).

Of the 10 studies reviewed in this section, 9 showed a positive correlation between depression and obesity. Although the methods and measures were different for each study, there appears to be a consistent link between both depression and obesity in cross-sectional research, especially in females.

Case-Control

Felitti (1993) investigated adult obesity and its relationship with childhood sexual abuse, depression, and family dysfunction in a case-control study of 100 significantly overweight subjects and 100 always-slender subjects. Each subject in this study was interviewed and assessed for the presence or history of depression, childhood sexual abuse, and several other variables relating to family dysfunction. Pearson chi-square tests were used to determine differences between the control and study groups. The results revealed that prolonged or recurrent depression was found among 57% of the obese group and only 22% of the control group. This again adds to the body of evidence that there seems to be a clear and significant association between depression and obesity.

Review Articles

McElroy et al (2004) constructed a review exploring the relationship between mood disorders and obesity, using literature published between 1966 and 2003. Researchers in this study used several terms including, obesity, overweight, depression, and anti-depression to perform a MEDLINE search of the literature. The different studies that were located were categorized into each of their respective statistical designs, and then conclusions were drawn by the researchers based upon the combined results of the studies.

Evidence from clinical studies reviewed in McElroy et al. (2004) suggest that children and adolescents with major depressive disorder may have increased risk of developing overweight, and obese individuals seeking weight-loss treatment may have higher levels of depressive disorders. Evidence from the community studies that were reviewed suggested that obesity and major depressive disorders are associated in females. In addition, abdominal obesity may be associated with symptoms of depression in males and females, and depression with atypical symptoms in females is more likely to be associated with overweight than in females who have depression with typical symptoms.

Conclusion

Of the several studies reviewed, many demonstrated a significant correlation between depression and obesity. Prospective studies where children were followed into adulthood generally showed a significant association between pediatric depression and adult BMI scores, especially in females. Cross-sectional data that were presented demonstrated a strong association between depression and obesity, and again the strongest results were found among female subjects. In addition, the case-control study reviewed also revealed higher rates of depression among obese subjects when compared with always-slender subjects. Furthermore, evidence from the review article suggested that depression and obesity are related in females, and children and adolescents with major depression may be at greater risk for obesity.

Finally, prospective studies among adults demonstrated a positive association between depression and body weight variability, and between depression and overweight. However, one prospective study demonstrated that obesity was predictive of depression, but depression was not predictive of obesity.

Although a great deal of research seems to suggest there is a significant association between depression and obesity, much of the evidence presented is derived from studies different from the proposed investigation for many reasons. First, a large body of the current literature is from cross-sectional studies. Although these studies are helpful in demonstrating a correlation between depression and obesity, they do not show causality. In addition, prospective studies among children deal with an entirely different population than the proposed study, and subjects for these studies undergo numerous physiological and environmental changes during the course of the study.

A final reason the proposed study differs from the current literature is that there are very few prospective studies performed among adults, and studies among this population vary so greatly in the demographics of the subjects that it is difficult to make conclusions based on the small body of evidence. For example, subjects in Hasler et al. (2004) were 19 at baseline and at the age of 40 for follow-up, whereas subjects for Roberts et al. (2003) were all over the age of 50 for the study. In addition, each of the studies reviewed utilized BMI as an outcome measure, whereas the proposed study will investigate changes in body weight as well as body fat percentage change over time, as measured by the Bod Pod. It is well established that Bod Pod is a much more accurate representation of overweight and obesity status than simply body weight.

In conclusion, the proposed study will likely make a significant contribution to the literature because a prospective cohort design will be used to investigate a sample of middle-aged female subjects. In addition, more precise measurement methods will be utilized in this study than have been employed in previous studies.

Chapter 3

Methods

The primary objective of the proposed study is to research prospectively the extent to which measured depression affects the risk of gains in body fat percent and body weight, utilizing data from the Brigham Young University Lifestyle Study. A secondary objective will be to determine the influence of potentially confounding factors on the relationship between depression and weight gain.

Design

A prospective cohort design was utilized to conduct the BYU Lifestyle Project. Baseline data were collected between 1998-1999 at Brigham Young University. Follow-up data were collected 20 months later during the second phase. There was no intervention or treatment between the two data collection periods.

Subjects

A total of 283 female subjects participated in the baseline phase of the BYU Lifestyle Project. In order to be enrolled in the study, subjects were required to be between the ages of 35 and 45 years, have a BMI <30 kg/m^2, and be a non-smoker. In addition, at baseline, subjects were required to be pre-menopausal, not pregnant, and not planning to become pregnant during the duration of the study. After almost two years, approximately 220 women participated in the second phase of the cohort study. Each subject signed an informed consent form that was approved by the university IRB at baseline and at follow-up.

Instrumentation and Measurement Methods

For the proposed study, six different variables will be examined. These variables include depression, body weight, body composition, physical activity, energy intake, and age. Each variable was measured at baseline and again at follow-up for all subjects.

Depression

Depression was assessed utilizing the General Well-Being (GWB) Schedule. The GWB schedule is a self-report instrument which contains 18 items that contribute to the total score. The instrument also contains six subscales which measure health worry, energy level, satisfying-interesting life, depressed-cheerful mood, emotional-behavioral control, and relaxed versus tense-anxious (Fazio, 1977). When the items in the schedule are combined, they offer an indication of well-being and distress (Taylor, Poston, Haddock, Blackburn, Heber & Heymsfield, et al., 2003).

The GWB schedule was developed by the National Center for Health Statistics (NCHS) after pre-testing on 373 adults, and was later administered as part of the Health and Nutrition Examination Survey from 1971-1975. Since then, the GWB schedule has been used in several large-scale studies (Fazio, 1977), and has also been translated into many different languages for use in other countries (Nakayama, Toyoda, Ohno, Yoshiike, & Futagami, 2000; Poston, Olvera, Yanez, Haddock, Dunn, & Hanis, et al., 1998; Taylor et al., 2003).

The validity of the GWB schedule was investigated by Fazio (1977) in a study utilizing 195 college students. The study compared the GWB schedule with several other self-report scales, and also compared each scale against interviewer ratings of current depression. The results of the study demonstrated that the GWB schedule "was clearly better than most of the other measures in its strength of relationship with the interviewer rating of depression" (Fazio, 1977, p.12). In addition, of the 28 scales and subscales investigated in the study, the GWB schedule was found to be "the single most useful instrument in measuring depression" (Fazio, 1977, p.12). Therefore, the GWB schedule was selected as the measurement tool for depression in the current study. Each subject in the BYU Lifestyle project completed the GWB schedule at baseline and follow-up.

Body Weight

Body weight was measured utilizing an electronic scale (Tanita Corp, Japan) that was calibrated daily using known weights. Readings from the scale were given via a computer interface to the nearest 0.01 lb (0.005 kg). Each subject was measured after using the restroom, and while wearing only a bathing suit provided by BYU. In addition, subjects were asked not to eat during the three hours prior to their scheduled weighing. Subjects were weighed at both the first and second appointments, and an average of the two measurements was used as their body weight.

Body Fat

Reliability of the Bod Pod was assessed utilizing 100 subjects from the original study cohort. A test-retest protocol was employed with each subject repositioned between tests, and an intra-class correlation of 0.999 ($p < .001$) was found between the two Bod Pod tests (Bailey, Tucker, Peterson, LeCheminant, 2001).

Validity of the Bod Pod utilized in the proposed study was examined with concurrent testing using Dual Energy X-ray Absorptiometry (Hologic 4500W, Bedford, Massachusetts). A total of 100 subjects from the original cohort also participated in this validational study. Pearson correlation between the two measures of body fat percentage was 0.94 ($p < .001$), and intra-class correlation was 0.97 ($p < .001$).

Ballard, Fafara, and Vukovich (2004) also demonstrated the validity and reliability of the Bod Pod utilizing 47 female subjects. All subjects were assessed for body composition by both the DEXA and the Bod Pod machines. The results of the study revealed that there were no significant differences between the DEXA mean and the Bod Pod mean.

Further evidence of Bod Pod reliability was demonstrated in a study of 980 subjects by Noreen and Lemon (2006). Each participant was assessed two times for body composition in the Bod Pod. Statistical analyses of the testing revealed no significant differences between the first and second tests.

All subjects reported to BYU to be assessed for their individual body fat percentage. Subjects were provided with a bathing suit and swim cap to wear during testing, and they were also instructed not to eat or exercise four hours prior to testing. The Bod Pod was calibrated each day with a known volume cylinder. Testing was conducted and repeated until two of the tests were within one percentage point of measured body fat from each other. The results of the two tests were then averaged for a final index of body fat percentage.

Physical Activity

Physical activity will be objectively assessed utilizing MTI (formerly known as CSA) monitors (Shalimar, FL). These monitors have demonstrated high-level validity and reliability for measuring physical activity. Welk, Schaben, & Morrow (2004) examined the reliability of four different accelerometer types: MTI/CSA, Biotrainer Pro, Tritra-R3D, and Actical using college-aged participants. Each subject in the study underwent three trials in which a series of 5-minute bouts of walking were followed by a 1-minute standing rest period. Statistical analyses demonstrated that MTI/CSA had the least amount of variability and the highest overall reliability of the differing accelerometer types.

At baseline, a pilot study of 15 subjects from the Lifestyle Project cohort was conducted to further investigate the validity and reliability of the MTI/CSA monitors. The results of the pilot study showed that the MTI/CSA monitors could detect differences in walking and jogging speeds of as little as 0.1 mph and differences in grades as small as 1%. In total, subjects were tested while performing 17 different activities. Two to four days later, subjects participated in the same 17 activities. Total activity counts for the first set of activities were compared to the same activities performed the second time, and the test-retest intraclass correlation was 0.98 ($p < 0.001$), showing superior reliability.

All subjects were instructed to position the MTI/CSA monitor over their left hip, in line with the middle of the lateral aspect of the leg, around the waist. The monitors were worn at all times, for seven consecutive days except when bathing or participating in water activities.

All of the MTI/CSA monitors used in the current study were programmed to sum physical activity into 1-minute epochs. These 1-minute intervals were then collapsed into

10-minute epochs. Across the seven days, subjects had 1008 total epochs. The sum of all activity counts across the 1008 epochs was used to index total physical activity.

Energy Intake

The assessment of energy intake was performed using weighed 7-day diet records. This method is considered to be the most precise measurement of energy intake in the field (Willett, 1998). In addition, 7-day food records have been shown to be the most representative of actual intake in research subjects (Willett).

Each subject in the current study was instructed on how to weigh all food and drink that was ingested during the week using an Ohaus 2000 electronic scale (Florham Park, NJ). Subjects were also instructed to record on diet logs everything they ate or drank during the 7-day period. If the total amount of calories consumed by the subjects was less than 130% of estimated resting metabolic rate, they were asked to redo the dietary log.

Subjects were strongly counseled to maintain their normal diet throughout the week, rather than trying to improve their eating habits. In addition, subjects were informed that changing their normal eating patterns could jeopardize the study. All dietary logs were analyzed by a Registered Dietitian utilizing the ESHA research software program, version 7.4 (Salem, OR).

Procedure

Baseline data were collected in a series of two appointments that were scheduled eight days apart. All appointments for subjects took place in the Human Performance Research Center at Brigham Young University. At baseline, risks and benefits of the study were explained and subjects were assured that all data collected by the researchers would remain confidential. In addition, each subject signed an informed consent that had been approved by the IRB.

During the first appointment, subjects were instructed on proper usage of the MTI/CSA monitors, and how to correctly weigh and record dietary intake. Subjects were also assessed during this time for height, weight, and Bod Pod measurements. Furthermore, subjects completed the GWB schedule.

Following the first appointment, subjects were contacted every other day to ensure compliance with the study parameters. During the week, subjects weighed and recorded dietary intake and wore the MTI/CSA monitors at all times except when bathing or participating in water sports. After eight days, subjects returned to the Human Performance Research Center to turn in their dietary logs and MTI/CSA monitors for analysis. Subjects were also weighed at this time in the same manner as described previously.

Approximately 20 months after the baseline assessments, subjects were invited to come in for a follow-up evaluation. During the follow-up appointments, the same measurements that were taken at baseline were repeated. At both time periods, after the data were collected and analyzed, the results were sent to each of the subjects along with a $25 gift certificate.

Data Analysis

All statistical analyses will be computed using SAS software, version 9.1 (SAS Institute, Inc., Cary, North Carolina). At baseline and follow-up, descriptive data (means, standard deviations, etc.) will be generated for each variable used in the study. Subjects will be divided into quartiles based on individual GWB (depression) scores and the middle two groups will be collapsed, forming three total groups.

The extent to which subjects in the three GWB groups differ regarding weight and body fat percentage gains over the study will be evaluated using ANOVA employing the SAS GLM technique. The extent to which potential confounders, such as age, physical activity, and energy intake, considered individually and combined, influence the relations between depression and weight gain across time will be measured using partial correlation.

The Least Squares Means procedure will be used to generate means adjusted for the covariate(s). Additionally, subjects will be classified into three groups based on whether they lost weight, maintained weight, or gained weight across the study period. Subjects will also be categorized into groups based on whether they lost body fat, maintained body fat, or gained body fat across the study period. Relative risks with 95% confident intervals will be calculated based on incidence rates to determine the extent to which depressed subjects are at increased or decreased risk of gaining weight over the investigation. Alpha will be set at the 0.05 level for all of the statistical analyses.

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