THE EFFECTS OF WEIGHT LOSS AND EXERCISE ON QUALITY OF LIFE

by

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PURPOSE: Health-related quality of life (HRQOL) is typically lower in overweight and obese populations compared to individuals of normal weight. Combined interventions of diet and exercise may improve HRQOL in this population, but the physiological predictors of these improvements are not well known. The primary purpose of the present study was to investigate the impact of weight loss and aerobic exercise on HRQOL as measured by the SF-36 in an overweight and obese population. Secondly, we sought to determine the impact of physiological mediators, such as body composition, weight loss, aerobic fitness, and insulin, glucose, and cholesterol levels on improvements in HRQOL. METHODS: The present study utilized data from the weight loss phase of the Prescribed Exercise to Reduce Recidivism After Weight Loss pilot (PREVAIL-P) study. This intervention lasted 10 weeks and consisted of aerobic exercise on a treadmill, the OPTIFAST medically supervised weight loss program, and weekly lifestyle education classes. All measurements were taken at baseline and 10 weeks, following the weight loss intervention. For primary outcome measures, HRQOL was assessed using the SF-36v2. For secondary measures, weight was measured using a physician beam scale, aerobic fitness was assessed using a modified Balke protocol with a metabolic cart, body composition was assessed using a DEXA scan, and a blood draw sent to LabCorp was used to measure insulin, glucose, and cholesterol levels. RESULTS: The sample included 36 participants (mean age=46 years; 80.6% female). We observed significant improvements in all domains of HRQOL and CVD risk factors, with a mean clinically significant weight loss of 9.3%. Improvements in several of the SF-36 domains were significantly associated with weight loss, reductions in cholesterol, and changes in body composition. When controlling for weight loss, all correlations became non-significant except the association between LDL and vitality. All HRQOL improvements were also significantly correlated with baseline SF-36 scores. CONCLUSION: Results from the present study suggest that a combined OPTIFAST weight loss and aerobic exercise training program may lead to improvements in HRQOL, which may be dependent upon baseline HRQOL levels and overall weight loss. Beneficial improvements in HRQOL did not appear to be limited by lean mass changes with weight loss. This knowledge will help in designing effective treatment programs and interventions to improve HRQOL in overweight and obese individuals.

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1. Health Related Quality of Life (HRQOL)
2. 36-Item Short Form Health Survey (SF-36)
3. Quality of life (QOL)
4. Activities of daily living (ADLs)
5. World Health Organization (WHO)
6. Physical component summary (PCS)
7. Mental component summary (MCS)
8. Kilocalories per kilogram of body weight (KKW)
9. Cardiorespiratory fitness (CRF)
10. Cardiovascular disease (CVD)
11. Electrocardiogram (ECG)
12. Rating of perceived exertion (RPE)

Chapter I: Introduction

Health-related quality of life (HRQOL) is defined as the subjective evaluation and reaction to health or illness.[1] It reflects many aspects of the ability to perform daily activities and is commonly measured through the 8 domains of the 36-Item Short Form Health Survey (SF-36).[2] Overall quality of life (QOL) can be influenced by a number of lifestyle factors (e.g., physical activity, nutrition, sleep habits, stress management). More specifically, overweight and obesity have especially shown a negative correlation with HRQOL.[3-5] A higher BMI is associated with increases in all-cause mortality and the chronic illnesses that are associated with obesity can ultimately become a major predictor of impaired HRQOL.[6] With the increase in obesity level, HRQOL decreases and this negative impact often seems to be more pronounced on the physical domains of the SF-36.[7,8] Ultimately, activities of daily living (ADLs) such as carrying groceries, climbing stairs, bathing, or kneeling down become much more difficult for obese individuals compared to individuals of normal weight.[9] Among other things, this can reduce productivity at work, decrease social interactions, and lead to an individual not participating in activities that were once enjoyed.[9,10] Thus, interventions that improve HRQOL may prove beneficial in an overweight and obese population.

Although obesity negatively impacts HRQOL, improvements have been observed among overweight and obese individuals following aerobic exercise interventions.[11,12] Furthermore, combined interventions of dietary weight loss with the addition of exercise have proven most beneficial for producing these changes.[13] The overall magnitude of improvement in HRQOL following interventions is not clear, as there is inconsistency in findings for improvements in the different domains of the SF-36. A systematic review by Bize et al.[14] observed a range of increased scores on various domains of the SF-36 to be 0.15 to 13.7 points. Others have demonstrated improvements as great as 16 or 22 points on certain domains of the SF-36.[15] There are also conflicting findings regarding the optimal intensity and dose of exercise for improving HRQOL, as well as which domains of the SF-36 are influenced to a greater degree. Some research, such as that by Svensson et al.,[12] supports the use of high intensity exercise, while others have found similar improvements with moderate intensity.[16] Regarding the domains of the SF-36, the physical domains are often impacted to a greater degree compared to the mental domains.[6,17] Similar to other researchers such as Katz et al. and Korhonen et al., de Zwaan et al.[6] demonstrated a dose-response association between BMI and physical HRQOL impairment ($r=-0.56$, $p<0.001$), but no significant association was found between BMI and mental HRQOL.

Even though combined diet and exercise interventions have led to improvements in HRQOL in individuals who are overweight or obese, the physiological mediators of these changes are not well established. The influence of weight loss and improvements in aerobic fitness have been investigated as mediators in previous research, but the findings are not conclusive. For example, weight loss has been shown to be correlated with improvements in HRQOL in some studies,[18,19] while others show no significant effects of weight loss.[20] Similarly, the association of improvements in fitness with improved HRQOL has varied, with some research, such as that by Bowen et al.[11] demonstrating an association and others like Svensson et al.[12] showing fitness to be independent of changes in HRQOL.

Many of the previous studies including HRQOL and diet and exercise interventions have been completed in psychological settings, therefore the influence of potential physiological mediators on HRQOL improvements has not been well-investigated. Although some factors such as weight loss and fitness have been considered, the findings are not consistent. Physiological factors such as cardiorespiratory fitness (CRF), body composition (lean vs. fat mass changes), weight loss, and insulin, glucose, and cholesterol levels may serve as mediators for the changes in HRQOL after combined diet and exercise interventions. One important reason for investigating the association with weight loss and body composition specifically, is that with weight loss there is a reduction of lean mass along with fat mass.[21] Loss of lean mass may be associated with poor HRQOL because individuals with lower muscle mass may have more difficulty performing ADLs.[22] Along with other health benefits, adequate muscle mass and strength are needed to easily perform daily activities like climbing stairs, getting off the floor, picking up objects, and walking distances. In addition to improving HRQOL, preserving lean mass should be a goal of these weight loss interventions. By investigating the effects of a combined intervention on HRQOL and identifying potential mediators, this study will contribute to the knowledge needed to effectively design and implement proper interventions of diet and exercise for improving HRQOL in overweight and obese individuals.

Purpose

The primary purpose of this study was to investigate the impact of weight loss and aerobic exercise on HRQOL as measured by the SF-36 in a population of overweight and obese individuals. Secondly, this study sought to determine the impact of physiological mediators, such as body composition, weight loss, aerobic fitness, and insulin, glucose, and cholesterol levels on improvements in HRQOL. For the purpose of this present study, data was utilized from the Prescribed Exercise to Reduce Recidivism After Weight Loss pilot (PREVAIL-P) study.

Hypothesis

First, HRQOL as measured by the SF-36 will improve following the combined diet and aerobic exercise intervention. We hypothesize that the greatest improvements will be seen in the physical health domains of HRQOL, specifically vitality, general health, and physical functioning. Secondly, changes in weight, aerobic fitness, body composition of lean and fat mass, and insulin, glucose, and cholesterol levels will serve as mediators for improvements in HRQOL.

Delimitations

This present study included the use of individuals classified as overweight or obese class 1 or 2 and between the ages of 30-65 years old. Participants were from Greenville, NC and the surrounding counties. The OPTIFAST weight loss program was used for the diet intervention and supervised aerobic exercise on a treadmill was performed at moderate intensity (50-75% VO_2max) for the exercise intervention. The duration of the combined intervention was 10 weeks.

Chapter II: Review of Literature

Obesity represents a growing problem which is not only associated with health specific concerns, but also impacts HRQOL.[3,5,6] Diet and exercise interventions may improve HRQOL, but the mediators of these improvements are not well known. The purpose of this study is to investigate the effects of a combined diet and aerobic exercise intervention on HRQOL in overweight and obese individuals and to assess the impact of potential mediators such as body composition, weight loss, aerobic fitness, and insulin, glucose, and cholesterol levels on changes in HRQOL. This review of literature will examine the following topics: impact of obesity on HRQOL, influence of exercise and weight loss on HRQOL, benefits of a combined diet and exercise intervention, and potential mediators for changes in HRQOL.

Health-Related Quality of Life

In 1948, the World Health Organization (WHO) defined health as a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity.[23] QOL is defined as an even broader concept than health, encompassing many factors including the ability to function in everyday life and personal evaluations of well-being.[24] More specifically, HRQOL is the effect of a medical condition like obesity on overall well-being and physical functioning.[25] Furthermore, it is a multidimensional construct encompassing emotional, physical, social, and subjective feelings of well-being which reflect subjective evaluation and reaction to health and illness.[3] Physical HRQOL can serve as a general indicator of daily functioning and the ability to perform daily tasks is influenced by beliefs, experiences, and perceptions related to QOL.[18] There are several indicators of HRQOL, including physical and social functioning, bodily pain, energy, and mood and impaired HRQOL can lead to one abandoning many activities that were previously enjoyed.[3,10,26] The SF-36 is one of the most widely used measures in obesity research to evaluate HRQOL. This assessment measures HRQOL along 8 domains: physical functioning, role limitations because of physical health problems, bodily pain, general health perception, vitality, social functioning, role limitations because of emotional problems, and general mental health. Two summary measures are also produced: the physical component summary (PCS) and mental component summary (MCS).

Impacts of Obesity on HRQOL

Obesity is a major health concern and if the increase in obesity rates continue, up to 57.8% of the world's adult population could be overweight or obese by 2030.[27] Obesity is a complex, multifactorial disease that develops from the interaction between genetics and the environment.[28] The condition negatively affects HRQOL, with previous data suggesting that overweight men and women lost 270,000 and 1.8 million quality adjusted life years, respectively, relative to their normal-weight counterparts.[29] This is one indication of the great impact that overweight or obesity has on overall HRQOL.

Obesity is associated with many chronic diseases including type 2 diabetes, metabolic syndrome, cardiovascular disease (CVD), hypertension, and some cancers.[30] The risk of suffering from any chronic illness was independently associated with BMI and increased linearly from 35% to 68% of those who are morbidly obese.[31] Additionally, in a population of apparently healthy adult men and women, cardiometabolic factors such as high blood pressure, high blood glucose, low HDL cholesterol, and high triglyceride concentrations worsened linearly with increasing BMI.[9]

In addition to the health specific concerns, obesity has an adverse effect on HRQOL.[4] The condition impacts the capacity to live a full and active life, with a negative effect especially on areas such as daily functioning, mood, perceived health, and self-concept.[1,6] This is generally associated with lower responses on many of the domains covered through the SF-36.[5] For the physical functioning domain specifically, daily tasks such as vigorous activity, walking more than a mile, lifting/carrying groceries, climbing several flights of stairs or bending, kneeling, and stooping may be impaired with obesity.[9] Also, obesity can lead to the earlier onset of disability, which often creates worse HRQOL and can lead to one leaving the workforce at an earlier age.[11] For example, the odds of reporting a work limitation due to physical health was 2.1 times higher for women with a BMI of 35-39.9 kg/m^2 compared to leaner women.[9] Increasing longevity is an important goal for any population, but it is also crucial to maximize HRQOL.[16]

Obesity adversely affects many of the domains of HRQOL as evaluated by the SF-36.[3-5] Overall, as the level of obesity increases, the impairment in HRQOL appears to be greater.[7] This relationship is demonstrated in populations of both men and women, with the physical domains primarily impacted to a greater degree than the mental.[7] A significant negative correlation between BMI and physical HRQOL has been established, while this association is not consistently seen with the mental components.[6,32] Although conclusions of previous research have varied on the degree of physical impairment, decreases as great as 16 points in physical HRQOL have been observed.[6] In a cross-sectional study by Anandacoomarasamy et al.[4], the SF-36 was used to compare HRQOL in 163 obese subjects with a mean BMI of 41.8 ± 6.7 kg/m^2 to age-and gender-matched population norms. Lower scores for the majority of SF-36 physical components (e.g. physical functioning, role physical, bodily pain, and general health) and most emotional components (e.g. vitality, social function, role emotion, and mental health) were observed for the obese group.[4] Furthermore, a dose-response relationship between BMI and the degree of HRQOL impairment has been observed, with HRQOL decreasing with increasing level of obesity.[3,7] A meta-analysis from 2012 demonstrated a clear dose-response relationship across all categories, with severely obese individuals reporting a reduced HRQOL score by 9.7 points ($p<0.001$).[7] Castres et al.[8] also investigated differences in HRQOL among obese subgroups by separating 69 obese individuals into one of 3 classes based upon BMI. After analyzing SF-36 scores, it was found that PCS scores were approximately 10 points lower in class 3 than class 1 and class 2 ($p<0.001$).[8] However, no significant difference was observed in the MCS scores among the 3 groups.[8] These results demonstrate that physical HRQOL especially, is worsened by severe obesity as compared to other obesity classes. In agreement with the findings of Castres et al.[8], those with severe obesity have reported the lowest HRQOL scores compared to individuals of normal weight.[33,34] Fontaine et al.[35] demonstrated this impairment in HRQOL among 312 individuals seeking outpatient treatment for obesity at a weight-management center. When compared to US population norms, the obese participants reported substantial decrements in HRQOL.[35] As seen previously, the impact of obesity on HRQOL varied with severity of obesity, with the morbidly obese (mean BMI = 48.7 ± 8.1) scoring worse in 6 out of the 8 SF-36 domains ($p<0.05$).[35] These differences were most pronounced in the bodily pain and the vitality domains.[35]

There is some controversy on whether BMI is related to both physical and mental health or only the physical components of HRQOL.[6,35] Some findings support the decrease in all aspects of HRQOL among obese individuals,[10,35] while a large number of others have found no changes with mental health components.[21,22,24] In 1996, Fontaine et al.[35] found an increased BMI to be associated with decreased HRQOL on all 8 subscales of the SF-36, as compared to US population norms; however, bias may serve as a limitation of this study as it was completed with participants who were already seeking weight-loss treatment. Other researchers have also shown the effect of obesity on physical and mental health to be similar.[10] In contrast, BMI affects the physical component more than the mental.[6,7,17,32] A cross-sectional controlled study by de Zwaan et al.[6] assessed HRQOL using the SF-36 among 640 individuals. No association was found between BMI and mental HRQOL even though a negative and significant correlation was found with the physical component ($r = -0.56$; $p < 0.001$).[6] In this study, on the PCS, normal weight individuals scored a mean 52.4 points, obesity grade 1 scored 47.1 points, obesity grade 2 scored 47.6 points, and obesity grade 3 scored 36.3 points.[6] This same significant correlation was not seen with the mental components, as normal weight individuals scored 49.1 points, obesity grade 1 scored 46.5 points, obesity grade 2 scored 47.4 points, and obesity grade 3 scored 47.4 points.[6] The MCS scores were more similar between obesity classes compared to the PCS scores.[6]

Using data from the Medical Outcomes Study, Katz et al.[17] also found no significant differences for scores on the mental health scale, but patients who were overweight, patients in class 1 obesity and class 2 and 3 obesity demonstrated significantly lower physical functioning scores on the SF-36, by 3.4, 7.8, and 13.8 points, respectively ($p \leq .001$).[17] Similarly, using healthy middle-aged subjects (n=1187), Korhonen et al.[32] found that all physical HRQOL components decreased with increasing BMI ($p < 0.001$) in women when adjusted for age and poorer physical functioning in men showed linearity with increasing BMI ($p=0.002$). Although the magnitude of the correlation was quite weak, PCS scores were inversely correlated with BMI in both men ($r=-0.10$) and women ($r=-0.25$); However, the MCS scores did not differ between BMI categories for either sex ($p=0.16$).[32] A meta-analysis of 8 studies by Ul Haq et al.[7] also showed a dose relationship where those with higher BMI had reduced physical HRQOL ($p<0.001$). Mental HRQOL was not significantly different among obese individuals, until class 3 obesity ($p=0.018$), where it was significantly reduced.[7]

After reviewing several studies, Fontaine and Barofsky[3] also concluded that obesity appears to have a greater effect on the physical aspects of HRQOL as compared to the mental components. Results of Metz et al.[36] are consistent with previous conclusions made by Fontaine and Barofksy, as the physical and mental component summaries of the SF-12, a shorter version of the SF-36, were used to investigate HRQOL among 123 primary care patients 35 years or older and with a BMI of 25 kg/m^2 or higher.[36] This sample of participants scored a mean 7.0 points lower on the PCS as compared to population norms ($t=7.8$, $p<0.0001$).[36] Poorer mental health scores were also seen in the overweight and obese participants, with this sample scoring a mean 4.85 points lower as compared to population norms ($t=6.09$, $p<0.0001$).[36] The PCS was significantly associated with BMI ($r=0.22$, $p<0.05$), but no differences were seen in MCS scores among BMI groups.[36] The greater effect on physical health as seen in overweight and obese individuals may be partly explained by actual physical restrictions due to excess body weight.[36] Additionally, with an increasing prevalence of obesity, being overweight may be perceived as normal, potentially decreasing the impact on one's mental health.[7] Overall, the impact of overweight and obesity on HRQOL appears to be more pronounced in physical dimensions as compared to the mental dimensions.

Obesity, Exercise, and HRQOL

In addition to the SF-36 being used to establish the negative impact of obesity on HRQOL, it has also been used to assess the impact of exercise on HRQOL in overweight and obese individuals. Exercise may reduce obesity and improve physical functioning, making ADLs easier by improving features such as gait speed, strength, physical fitness, and prompting an increased energy level.[3,11,21] Previous literature has focused primarily on aerobic forms of exercise, with various intensities and durations being used. Even though exercise interventions have improved HRQOL, obese individuals are less likely to engage in adequate exercise for both weight reduction and health benefits in general.[32] Recognizing the importance of improved HRQOL, it is necessary to develop exercise programs of adequate frequency and intensity to induce improvements in HRQOL among overweight and obese individuals.

For changes in HRQOL following aerobic exercise, interventions of different exercise durations and intensities have shown improvements in HRQOL among various population groups. Using 45 minutes of moderate-to-vigorous intensity exercise 5 days of the week, Bowen et al.[11] investigated the effects of a 1-year aerobic exercise intervention in middle-aged sedentary women (n=274) with a BMI $\geq$ 25 kg/m^2 from the Physical Activity for Total Health Study. In this randomized controlled trial, the physical health, general health, and mental health scales from the SF-36 were used to measure HRQOL at baseline, 3 months, and 12 months. The intervention group showed significant improvement in general health with an increase in mean score of 79.95 at baseline to 86.1 at 3 months and 83.6 at 12 months ($p < 0.01$).[11] Mental health also improved for the intervention group at 3 months with a baseline score of 80 and a 3 month score of 85.2 ($p<0.01$).[11] At 12 months, changes in mental health scores approached significance with a score of 83.27 ($p = 0.08$).[11] This improvement in HRQOL following exercise is important in terms of increasing functioning and independence and making daily tasks such as bathing, getting dressed, walking, and climbing stairs easier.[9] Moreover, the improved HRQOL after exercise is associated with improvement in one's mood, level of functioning, and energy level, which presumably allows individuals to be more successful in accomplishing daily tasks including productivity with work and social interactions.[16]

Exercise Intensity and Dose

Aerobic exercise interventions of varying intensities have been used among overweight and obese individuals to improve HRQOL. Comparing moderate and high intensity exercise has produced inconsistent findings. Support for the benefits of high intensity exercise was given as Svensson et al.[12] randomized 176 healthy inactive individuals with a BMI $\geq$ 35 kg/m^2 into either a control group, a high intensity, or moderate intensity aerobic exercise group. The high intensity group completed 1 hour, 3 times per week of 85-95% maximal heart rate intensity, while the moderate group completed 30 minutes 3 times per week of 76-85% intensity.[12] The duration of the exercise sessions was 16 weeks, with the SF-36 being administered at baseline and upon completion of the intervention.[12] The high intensity group improved significantly on the MCS by 3.8 points ($p<.01$) and in four subdomains (physical functioning, general health, vitality, and mental health) whereas the moderate intensity group improved in only two domains (physical functioning and mental health).[12] Although changes in PCS scores were not significant in any group, greater increases were observed in the high intensity group with an average 2.0 point increase following the exercise intervention.[12] Although greater benefits were seen with high intensity training in this study, significant improvements in HRQOL have occurred even at moderate training intensities in other research. For example, Martin et al.[16] showed improvements in HRQOL in postmenopausal women training for various durations at an intensity of 50% VO2max for 6 months ($p<.001$).

In addition to exercise intensity, exercise dose has influenced changes in HRQOL. When considering that weight loss may be associated with improved HRQOL, it is important to consider that higher levels of exercise and physical activity (>2500 kcal/week) have been associated with better long term weight losses in both men and women ($p < 0.05$), which supports an association between activity levels and weight loss maintenance.[38] Various doses of exercise have been used in studies looking at HRQOL among overweight and obese individuals. Using the intensity of 50% VO2max, Martin et al.[16] established a dose response effect between HRQOL and exercise amount using data from the Dose Response to Exercise in postmenopausal Women (DREW) study. Participants were 430 sedentary, overweight or obese postmenopausal women ranging in age from 45-75 years with a mean BMI of 31.8 kg/m^2. Three exercise groups were assigned incrementally higher doses of energy expenditure: 4, 8, or 12 kilocalories per kg of body weight (KKW) per week. Individuals in these groups completed 3-4 supervised training sessions per week for 6 months. The trials resulted in a dose response effect of exercise on HRQOL for all aspects except bodily pain, with the 12 KKW group demonstrating significantly improved HRQOL compared to the control group ($P < .001$ to .04).[16] The 12 KKW group improved physical functioning by approximately 8 points ($p<0.01$), mental health by 4 points ($p<0.05$), role-physical by over 12 points ($p<0.05$), role emotional by close to 14 points ($p<0.01$), social functioning by 8 points ($p<0.001$), general health by 8 points ($p<0.001$), and vitality by close to 12 points ($p<0.01$).[16] Compared to the control group, the 4 KKW had significantly improved general health, vitality, and mental health scores.[16] General health improved by over 4 points ($p<0.05$), vitality improved approximately 10 points ($p<0.05$), and mental health improved approximately 4 points ($p<0.05$).[16] All 3 of the exercise groups improved social functioning with an approximately 4 point increase in the 4 KKW and 8 KKW groups ($p<0.05$) and an approximately 8 point increase seen in the 12 KKW ($p<0.001$).[16]

Alternatively, less improvements in HRQOL have been obtained following a higher exercise dose. Using data from the 2001 Behavioral Risk Factor Surveillance System, Brown et al.[39] found that not only was not participating in enough or any vigorous physical activity associated with poorer HRQOL, but also those individuals engaging in vigorous physical activity > 60 min/day or 7 days of the week were more likely to experience poorer HRQOL. Although HRQOL was assessed using several questions referencing QOL over the previous 30 days and the levels of physical activity were self-reported, the findings suggest that participation in moderate or vigorous activity every day of the week or for extended bouts may not be optimal.[39] Similarly, a 12 month randomly controlled exercise trial by Imayama et al.[40] with a greater exercise dose showed no significant differences in SF-36 subscales ($p > 0.05$) among sedentary middle-aged men and women, many of whom were overweight or obese. This aerobic exercise intervention consisted of 60 minutes a day with an intensity of 60-85% maximal heart rate, 6 days a week for a total of 360 minutes per week.[40] Three sessions each week were supervised, while the other three were completed at home. The intervention did not have a negative effect on HRQOL, but it also did not increase any aspects, suggesting that moderate doses may be more beneficial than high doses for improving HRQOL.[40] Further analysis of intervention effects by BMI and gender revealed that among overweight males, the vitality subscale score was significantly higher than controls ($p<0.01$), indicating some increase in HRQOL among these participants in particular.[40]

Obesity, Weight Loss, and HRQOL

In addition to exercise, the impact of weight loss on HRQOL among overweight and obese individuals has been investigated. Weight loss has been shown to improve HRQOL;[19] However, the relationship is not as clear as with exercise, as some findings suggest no significant effects of weight reduction on aspects of QOL.[16,20] Others have found improvements in HRQOL, even with modest weight loss.[20] Similar to the relationship between obesity and HRQOL, weight loss has been shown to have a greater impact on the physical components of HRQOL as compared to the mental aspects.[32,33]

Weight loss may be necessary to improve HRQOL as measured by the SF-36. Previous literature has demonstrated improvements in HRQOL following varying percentages of weight loss. Using data from the Nurses' Health Study cohort (n=40,098), Fine et al.[19] investigated the association between changes in weight and change in functional health status, as measured by the dimensions of the SF-36. In women younger than 65, weight loss of greater than 9.0 kg was associated with a 4 point improvement in physical functioning in women with a BMI $\geq$ 35.0 kg/m^2 ($p<0.001$), a 4 point improvement in vitality among those with an overweight BMI of 25.0-29.9 kg/m^2 ($p<.05$) and obese with BMI $\geq$ 35.0 kg/m^2 ($p<.05$), and a 3 point improvement in bodily pain scores among those with a BMI 30.0-34.9 kg/m^2 ($p<.01$).[19] For women older than 65, weight loss of 9.0 kg or more was associated with a 6.9 point improvement in physical functioning scores among women in the 2 highest BMI categories ($p< 0.05$).[19]

Intervention studies are also consistent with these findings. In a 6-month lifestyle intervention consisting of a low-calorie eating plan, weekly aerobic exercise goals, and behavior modification, Ross et al.[18] found weight loss to be correlated with all subscales of the SF-36 except role physical and role emotional domains and found it to mediate the relationship between physical fitness and increases for the general health and vitality subscales. A mean weight loss of 10 kg was achieved among the obese women and the weight loss was significantly associated with improvements in physical functioning (r= -0.21, p=0.001), bodily pain (r=-0.14, p=-0.021), general health (r=-0.27, p=0.001), vitality (r=-0.27, p=0.001), and mental health (r=0.02, p=0.016).[18] Fontaine et al.[15] also found weight loss of 8.6 +/- 2.8 kg over 13 weeks in 38 overweight individuals to be associated with a significant increase in many of the SF-36 subscales including a mean 9.4 point increase in physical functioning ($p<0.0001$), 14.5 point increase in role-physical ($p<0.0001$), 14.3 point increase in general health ($p<0.0001$), 21.9 point increase in vitality ($p<0.0001$), and 6.3 point increase in mental health ($p<0.001$), but no increases were seen in the bodily pain, social functioning, or role-emotional subscales. The largest improvements were seen on the subscales of vitality, role physical, and general health ($p=0.0001$). Imayama et al.[13] further demonstrated improvement in weight as a possible mediator of intervention effects on HRQOL. Over 12 months, a diet group decreased weight by 7.2 kg, an aerobic exercise group decreased weight by 2.0 kg, and a combined diet and exercise group decreased weight by 8.9 kg as compared to controls.[13] Weight loss among these groups predicted changes in some of the SF-36 domains, including increased physical functioning ($r=0.28$, $p< 0.001$), role physical ($r=0.18$, $p<0.001$), vitality ($r=0.36$, $p<0.001$), and mental health ($r=0.13$, $p=0.006$) scores.[13]

Others have reported no significant effects of weight reduction on HRQOL.[20,41-43] These findings have been seen in reviews of various populations and treatment groups, as well as intervention studies among overweight and obese individuals. A review of 34 randomized controlled trials of weight loss by Maciejewski et al.,[43] showed no consistent significant effect of weight change on HRQOL, with only 9 trials demonstrating improvements in one or more domains of generic HRQOL measures. Similarly, a systematic review by Warkentin et al.[41] reported no significant association between weight loss and HRQOL improvements when using a contingency table approach ($p=0.067$ to $p=1$); however, a limitation of poor data reporting in many of the studies was acknowledged. In addition, in a systematic review of reviews, Kolotkin et al.[42] reported a lack of consistently demonstrated associations between weight loss and improved HRQOL as one review reported improvements in only 9 out of 34 randomized controlled trials using a generic assessment of QOL and another reported improvements in only 14 out of 36 trials.

A similar conclusion on the relationship of weight loss and HRQOL was made by van Gemert et al.[20] in an intervention study using data from the Sex Hormones and Physical Exercise (SHAPE-2) Study. Postmenopausal women (n=214) were randomized into a diet group which was given an energy restricted diet, an exercise group that performed combined aerobic and strength exercise, or a control group.[20] After 16 weeks, an average 6-7% weight loss occurred with no significant differences found in changes in HRQOL using the SF-36 PCS (p=0.24) and MCS (p=0.32) when comparing either intervention group to the controls.[20] Although not statistically significant, the exercise group showed larger improvements than the diet group in all domains.[20] One limitation cited for this study was the use of participants with relatively high HRQOL scores at baseline, which left little room for improvement.[20]

Further evidence suggesting no significant effect of weight loss on HRQOL was seen as Martin et al.[16] found changes in HRQOL to be similar for those who did and did not lose weight. When participants were divided into those who lost weight and those who maintained or gained weight after a previously discussed 6-month aerobic exercise intervention to examine changes in SF-36 subscale scores (p=.07 to .95), there were no significant differences in changes.[16] In agreement with Martin et al., Svensson et al.[12] found no significant correlations between changes in physical or mental subscales and weight reduction after a 16-week aerobic and strength-endurance exercise intervention. In contrast with the studies that found associations between weight loss and HRQOL improvements, Martin et al.[16] and Svensson et al.[12] did not include a diet component with the exercise intervention, which may suggest the importance of a dietary component as part of an intervention.[12,16] Regardless, these nonsignificant findings are support for achieving improvements in HRQOL after exercise, even without substantial weight loss.

Combined Weight Loss and Exercise

Intervention studies have commonly used lifestyle changes focusing on diet and behavior modification to reduce weight. A combination of diet and exercise has proved beneficial for reducing weight and improving HRQOL measured by the SF-36 among overweight and obese individuals.[13,15] One important benefit of this combined approach is that the addition of exercise to diet can reduce the losses of lean tissue that may occur with weight loss through diet alone.[21] Preserving lean mass should be a critical goal of all effective weight loss interventions.

Demonstrating the benefits of a combined approach, Fontaine et al.[15] placed 38 adult men and women on a reduced calorie, reduced fat diet and randomly assigned them to either a program of lifestyle physical activity designed to increase physical activity throughout the day or a program of traditional aerobic activity consisting of exercising 3-4 times per week. At the end of 13 weeks, there was an average weight loss of 8.6 ± 2.8 kg and significant differences in SF-36 scores were seen in 5 out of 8 domains, with the greatest improvements seen in general health improving 14.3 points (p=0.0001), vitality improving 21.9 points (p=0.0001), and role physical improving 14.5 points (p=0.0001).[15] No differences were reported between groups utilizing two different methods of increasing physical activity, indicating both were successful in producing improvements in HRQOL.[15] One limitation seen with this study design is the absence of a non-exercise control group.[15]

Further evidence for the effectiveness of a combined approach is seen in a randomized controlled trial by Imayama et al.[13] using sedentary, overweight or obese postmenopausal women from The Nutrition and Exercise for Women (NEW) trial. A 12-month intervention of diet, exercise, or combined diet and exercise was implemented to examine the effects on HRQOL.[13] The diet group received a reduced calorie weight loss intervention with the goal of a 10% body weight reduction, while the exercise group completed 45 minutes per day, 5 days per week of aerobic exercise at an intensity of 70-85% maximal heart rate.[13] The combined group received both the reduced calorie diet and exercise intervention.[13] As previously discussed, compared to controls the diet, exercise, and combined diet and exercise groups decreased body weight from baseline by 8.5% ($p<0.01$), 2.4% ($p=0.03$), and 10.8% ($p<0.01$) respectively.[13] For HRQOL, the combined group improved more aspects with larger increments of 5 to 11 points compared to the diet only or exercise only groups.[13] Compared to controls, the combined group demonstrated an average increase of 5.7 points in physical function ($p<0.0001$), 9.0 points in role-physical ($p<0.001$), 11.5 points in vitality ($p<0.001$), and 3.2 points in mental health ($p=0.01$).[13] The diet only group also increased mean vitality scores, but the combined group showed a larger increase ($p = 0.04$).[13] Interestingly and in contrast to findings of other studies, the exercise only group did not significantly improve any HRQOL subscales compared to controls.[13] This was potentially attributed to higher baseline HRQOL scores or exercise preferences among the participants in this group.[13]

Consistent with the findings of Fontaine et al. and Imayama et al., Villareal et al.[21] demonstrated the benefits of a combined intervention through a 1-year randomized controlled trial in 93 elderly obese adults (≥ 65 years). As seen in other studies, participants were randomly assigned to a diet group, exercise group, combined diet and exercise, or control group. In addition to HRQOL measures, physical function was also assessed. The diet group decreased body weight by 10% and the combined group decreased by 9% from baseline, while the exercise group decreased only by 1%.[21] PCS scores from the SF-36 increased in all intervention groups from baseline with a 15% increase in the combined diet and exercise group, 14% in the diet group, and 10% in the exercise group ($p<0.01$).[21] On a physical performance test that uses functional items that simulate ADLs, which would presumably contribute to overall QOL, the combined group experienced a 21% ($p<0.001$) increase from baseline as compared to a 12% ($p<0.001$) increase in the diet group and a 15% ($p<0.001$) increase in the exercise group.[21] The combined diet and exercise group also demonstrated more consistent improvements in strength, balance, and gait, all of which contribute to the ability to perform ADLs.[21] These findings are consistent with the literature suggesting that diet or exercise alone can improve physical functioning and HRQOL, but that a combination of both is more effective.

Rippe et al.[44] also demonstrated the benefits of a combined approach, but this intervention consisted of 12 weeks of a self-selected hypocaloric diet, progressively increased physical activity of choice, and weekly meetings for group support as compared to a control group. The intervention was implemented among 80 overweight women ages 20-49 years. In addition to HRQOL, cardiovascular fitness, body composition, and psychological inventories were completed before and after the study period. The intervention group lost a mean 6.07 ± 4.01 kg and decreased percent body fat from 36.8% to 32.5%.[44] Additionally, significant improvements were seen in VO_2 max as compared with baseline and controls with a mean increase from 28.9 ml/kg/min to 32.8 ml/kg/min ($p<0.0001$).[44] For HRQOL, the intervention group achieved significant improvements ($p<0.006$) with a 13.5 point increase in physical function ($p=0.0005$), 21.7 point increase in vitality ($p=0.0010$), and 10.4 point increase in mental health ($p=0.0029$) subscales of the SF-36.[44]

Fitness and HRQOL

Evidence for the association of fitness level and baseline HRQOL has been investigated limitedly in overweight and obese individuals without chronic conditions; However, an association has been established among other population groups. Sloan et al.[45] demonstrated that in healthy men ages 18-49 low CRF was associated with low PCS ($r=0.269$, $p<0.001$) and MCS ($r=0.078$, $p = 0.037$) scores on the SF-12. A submaximal test using a modified Balke protocol with extrapolation to age-predicted maximal heart rate was used to determine CRF. Although participants were not necessarily classified as overweight or obese which limits generalizability, the findings suggest a positive relationship between level of CRF and mental and physical components of HRQOL.[45] Additionally, Moratalla-Cecilia et al.[46] investigated the association of components of physical fitness with HRQOL in 67 women 40-65 years old. CRF was assessed with the 6-minute walk test and was associated with the mental components of the SF-36 ($r^2=0.266$, $p =0.002$).[46] If a similar positive relationship exists between fitness and HRQOL in overweight and obese populations, then improving fitness through exercise interventions may also improve HRQOL.

Just as weight loss has been investigated as a mediator of improvements in HRQOL, improvements in fitness have also been assessed. For some interventions, changes in fitness are independent of HRQOL improvements,[12,16,18] while others have found a significant association.[11,13] In the same way that Martin et al.[16] and Svensson et al.[12] demonstrated no correlation with changes in HRQOL and weight reduction, changes in HRQOL were also independent of changes in fitness in these studies. This counteracts the expectation that an increase in fitness would increase the ability to be active and therefore increase subjectively-experienced health and well-being.[12] Additionally, after a lifestyle intervention of a low-calorie diet and aerobic exercise program, Ross et al.[18] established that weight loss is a more significant contributor to improvements in HRQOL as compared to increased fitness, suggesting that improvements in fitness in the absence of significant weight loss may not improve HRQOL. Using linear regression analysis, improvements in fitness were significantly associated with general health ($\beta=0.012$, $p<.05$), health transition ($\beta=-0.001$, $p<.01$), and vitality ($\beta=0.014$, $p<.05$); However, after controlling for weight loss the association between improvements in physical fitness and these SF-36 domains became non-significant.[18] One possible reason cited for the more subtle changes in fitness compared to weight loss is that it is easier to observe weight loss than increases in fitness, so participants may attribute improvements in mobility and functioning to reduced weight.[18]

Contrastingly, Imayama et al.[13] suggested that increased aerobic fitness predicted 12-month improvements in the physical functioning domain ($r=0.16$, $p=0.0007$). In this study aerobic fitness increased by 0.17 L/min in the exercise group and 0.12 L/min in the combined diet and exercise group ($p<0.0001$ vs. control).[13] Bowen et al.[33] also found increases in fitness to be associated with physical functioning scores after 12 months of a moderate intensity aerobic exercise intervention ($\beta=1.54$, $p=0.01$). Studies such as these provide support for the independent association of improved fitness and improvements in HRQOL, but conflicting results are present so further investigation with reliable methods of assessing aerobic fitness is needed.

Mediators of Improvements in HRQOL

There is uncertainty regarding the mediators of improvement in HRQOL following weight loss and exercise interventions among overweight and obese individuals. Psychological variables including self-efficacy, social support, depression, and stress have been considered as mediators, as well as physiological variables like weight loss and improved fitness. When identifying mechanisms through which diet and exercise improve HRQOL, there is also evidence for improved psychological factors serving as predictors.[11,13,44] For example, Bowen et al.[11] found that high levels of social support were associated with high levels of mental health scores (β=0.15, p<0.01) and general health changes at 3 months (β=0.11, p=0.01) in middle-aged women completing 12 months of aerobic exercise. Imayama et al.[13] investigated predictors of change in HRQOL after a 12-month randomized controlled trial of diet, exercise, or combined intervention and also found positive changes in psychological variables including depression, stress, and social support to be significantly associated with four subscales of HRQOL: physical functioning, role physical, vitality, and mental health. For example, changes in perceived stress (r=-0.22, p<0.001) and social support (r=0.24, p<0.001) predicted increased physical functioning, reduced depression (r=-0.23, p<0.001) and improved social support (r=0.22, p<0.001) predicted increased role-physical scores, reduced depression (r=-0.42, p<0.001) and perceived stress (r=0.22, p<0.001) were associated with improved vitality, and decreases in depression (r=-0.55, p<0.001) and perceived stress (r=-0.51, p<0.001) predicted positive changes in mental health.[13] Additionally, in a study by Rippe et al.[44] several psychological variables improved following 12 weeks of a self-selected hypocaloric diet and increased physical activity. In this group a 5.7-point decrease in state anxiety (p=0.0022), 6.5-point increase in the vigor subscale of an assessment of mood (p=0.0006), and other improvements in overall self-worth and satisfaction (p<0.004) were seen.[44] Little association was found between changes in psychological measures and changes in physical measures, with most correlations being low and not exceeding r=0.30.[44]

While psychological mediators for the changes in HRQOL have been studied extensively, physiological and cardiometabolic changes have been studied more limitedly. Changes in weight and fitness are two of the potential physiological mediators that are seen in previous literature. As demonstrated by Imayama et al.[13] the impact of changes in weight and aerobic fitness on predicting improvements in HRQOL was assessed and increased physical functioning was found to be associated with changes in weight ($r=-0.28$, $p<0.001$) and aerobic fitness ($r=0.16$, $p<0.001$), while role-physical ($r=-0.18$), vitality ($r=-0.36$), and mental health ($r=-0.13$) scores were associated with reduced weight. Others such as Martin et al.[16] found no association with fitness, indicating that improvements in fitness may not be necessary to improve HRQOL when individuals increase physical activity. These conflicting results necessitate the need for further research on the association of these variables with HRQOL in overweight and obese individuals.

In addition to CRF, another potential physiological mediator of improvements in HRQOL is body composition changes. The changes with fat and lean mass represent important factors to examine among obese individuals, but related research on body composition and HRQOL is lacking. Villareal et al.[21] measured body composition changes in a one-year study where participants were assigned to a control group, diet group, exercise group, or combined diet and exercise group. Lean body mass decreased 3% and fat mass decreased 16% from baseline in the combined group.[21] In the diet group, lean body mass decreased 5% and fat mass decreased 17%.[21] In the exercise group, lean body mass increased 2% and fat mass decreased 5% from baseline.[21] Although these body composition changes were reported, there was no analysis completed for the association with changes in HRQOL. Castres et al.[8] also looked at fat mass which was measured by bioelectrical impedance analysis (BIA). In these participants, fat mass was investigated as a variable associated with HRQOL among obese subgroups and it was found that fat mass was negatively correlated with PCS ($p<0.001$) scores.[8] Other research on body composition changes in association with improvements in HRQOL is limited. Body compositional changes should be assessed as a possible mediator of improvement in HRQOL. One important reason for this is that with weight loss, lean mass is lost in addition to fat mass so preserving lean mass should be a priority during exercise and weight loss interventions. If the relationship between fat mass and lean mass changes serves as a mediator for improvements in HRQOL, then the amount of lean or fat mass lost may predict improvements in HRQOL.

There is also a lack of knowledge on the relationship of the SF-36 with insulin, glucose, and cholesterol levels. Associations have been seen at baseline, but previous literature is limited regarding associations in changes following diet and exercise interventions. For example, using data from the Whitehall II study, Kumari et al.[47] investigated biological predictors of physical and mental functioning in 4768 men and 2034 women participants over a mean duration of 3.15-year longitudinal study. For both women and men, there was a mean change of -1.5 in PCS scores and a change of -1.1 in MCS scores.[47] Fasting insulin (p=0.0002 in men and p=0.0039 in women) and decreasing HDL-cholesterol (p=0.0020 in men and p=0.0047 in women) were associated with a decline in PCS; However, total cholesterol was not associated.[47] As the variables associated with the PCS may represent insulin resistance, it was noted that identifying insulin resistance may be a potential area of intervention to prevent functional decline.[47] Furthermore, if these biological levels of insulin, glucose, and cholesterol change following an intervention, improvements in HRQOL may also be seen. Dehesh et al.[48] investigated the metabolic variables that influenced HRQOL most significantly among a group of 163 type 2 diabetics and 214 healthy individuals. In this population, PCS scores from the SF-36 were negatively influenced by LDL-C (P=0.008, β=−0.721), total cholesterol (P=0.006, β=–0.648), HbA1c (P=0.002, β=–0.878), and FBS (P=0.006, β=−0.769).[48] Although associations such as these have been noted at baseline, the literature is limited on the role of these cardiometabolic levels as mediators of changes in HRQOL following diet and exercise interventions. Knowledge of this association would aid in designing effective treatment programs that may improve insulin, glucose, or cholesterol levels, while also increasing HRQOL.

Effects of Weight Stigma and Body Image on HRQOL

Weight stigma and a negative body image may have a detrimental impact on HRQOL in overweight and obese individuals, especially in the mental domains.[36] Weight related discrimination is especially common among women.[50-51] This discrimination can lead to psychological problems such as depression, as well as the development of a poor body image and low self-esteem.[51] These negative impacts can ultimately affect an individual's mental HRQOL.

Latner et al.[50] examined the role of external weight-based discrimination and weight-based self-discrimination in the relationship between BMI and HRQOL in a sample of 81 women. There were significant associations seen between BMI and discrimination ($r=0.36$, $p=0.002$), internalized weight bias and both mental ($r=0.61$, $p<0.001$) and physical ($r=0.45$, $p<0.001$) HRQOL, and discrimination and physical HRQOL ($r=0.29$, $p<0.014$).[50] Furthermore, a significant part of the variance in physical HRQOL was accounted for by the interaction between BMI and internalized weight bias ($r^2 = 0.38$).[50] Although overweight and obesity may have a greater impact on the physical domains of HRQOL, the mental domains may be reduced due to factors such as stigmatization, social exclusion due to high body weight, and internalized weight bias.[36]

Impacts of Aging/Menopause on HRQOL

The changes that occur with the aging process can also have effects on HRQOL. More specifically, in women, the menopausal transition has been shown to have an impact on

HRQOL.[52-53] The hormonal and psychological changes that occur during this period may contribute to a negative effect and the decreased estrogen in the postmenopausal period may influence these problems.[52] Additionally, menopausal symptoms such as anxiety, depression, joint stiffness, insomnia, tiredness, hot flashes, and night sweats can be burdensome to those women who experience them.[53] Whiteley et al.[53] investigated the impact of these common symptoms on HRQOL. The presence of menopausal symptoms was associated with significantly lower MCS (45.8 vs 47.4, $p<0.05$) and PCS (46.8 vs 48.6, $p<0.05$) scores.[53] Women experiencing symptoms also reported significantly higher overall work impairment (16.1% vs 12.3%, $p<0.05$), which may contribute to impaired overall HRQOL.[53]

Mishra et al.[54] investigated the effects of changes during menopause transition on HRQOL in women participating in the Australian Longitudinal Study on Women's Health (ALSWH). For each domain of the SF-36, a general pattern of decreasing scores was seen across the menopausal categories (pre, peri, and post).[54] After adjusting for socio-demographic and behavioral factors, the baseline mean HRQOL scores were higher in premenopausal women than in any other transition group ($p<0.01$).[54] Similarly, Budakoglu et al.[52] investigated the effects of menopausal status on HRQOL in a cross-sectional study of women ages 40-80 years. Physical functioning, role emotional, role physical, general health, social functioning, and mental health scores were significantly higher in premenopausal women compared to the postmenopausal women ($p<0.05$).[52] The bodily pain scores were also higher for postmenopausal women ($p<0.05$).[52] Additionally, the scores for physical functioning, role physical, general health, and social functioning decreased with age among the postmenopausal women.[52] When the results were further analyzed by excluding women without any chronic disease, the differences were no longer significant except in the role physical, social functioning, and bodily pain domains.[52]

On the other hand, the menopause transition has shown little impact on overall HRQOL when adjusting for factors like symptoms, medical condition, and stress.[55] Using data from the Study of Women's Health Across the Nation (SWAN), Avis et al.[55] examined changes in HRQOL over the menopausal transition. Women were either pre or early perimenopausal at baseline and were followed for 6 annual visits.[55] After adjusting for variables such as chronological age, aging, and symptoms, menopausal status was independently associated with reduced physical role functioning ($p<0.001$).[55] The changes in HRQOL that are seen throughout menopause may be largely explained by symptoms related to menopause and aging.[53-55] Even so, the association between menopausal status and HRQOL should be considered, especially when implementing diet and exercise interventions to improve HRQOL among this population and specific age group.

Public Health Implications

Overweight and obesity are immense public health concerns that not only have detrimental consequences for the individual, but also negatively affect the overall health system, work force, and economy.[4] In addition to the increased risk of numerous diseases and health conditions, overweight and obesity are also associated with decreased HRQOL which can lead to even more negative effects. On the individual level, obesity and low HRQOL are associated with an increased risk of disability, which can impact an individual's ability to work and actively participate in the community.[4]

Another major issue is that obesity and the chronic conditions that are involved with it are associated with potentially high levels of healthcare costs.[56] Some direct costs include those for medications, procedures, and the management of chronic conditions, while the indirect costs include things such as absenteeism, disability, and premature mortality.[56] The weight loss interventions of combined diet and exercise may improve HRQOL in addition to decreasing weight and improving CVD risk factors.[13,15] These improvements will decrease the risk for chronic diseases and health conditions and may allow individuals to stay more active in their communities and workplace.[4] HRQOL improvements indicate better physical and emotional well-being which can lead to more productive individuals in the workforce and overall society and potentially lower healthcare costs.[9,11]

Furthermore, large increases in premature mortality are seen among overweight and obese individuals.[57] Using data from the Framingham study, Peeters et al.[57] reported that the probability of death increased with each higher BMI category. Compared to individuals of normal weight, obese women were 115% more likely to die before age 70 and obese men were 81% more likely to die before age 70.[57] The scope of public health, not only recognizes the importance of mortality and morbidity rates for measuring a population's overall wellbeing, but also emphasizes that HRQOL can provide a reflection of the prevalence of daily dysfunction and disability associated with chronic diseases and conditions, like obesity.[58] Increasing longevity is important, but maximizing HRQOL also needs to be a main priority for public health interventions among overweight and obese individuals.[16] There are many health benefits of increasing exercise and weight loss among this group, and improved HRQOL can be a large part of those benefits.

Although there are positive health, economic, and social implications for weight loss with diet and exercise, these lifestyle changes can be difficult to adopt.[14] Therefore there is a need for alternative motivational strategies other than simply risk awareness to prompt behavior and lifestyle changes.[14] There is often a tendency for individuals to underestimate their chronic disease risk so a demonstration of a positive association between weight loss and exercise and improved HRQOL may provide motivation for individuals to lose weight and become more physically active.[14] Increased HRQOL is often associated with better social functioning, a higher energy level, and improved overall health perceptions and these are all factors that may be appealing to individuals and prompt them to make lifestyle changes with diet and exercise.[3] Ultimately, the HRQOL improvements may be a more effective motivator than simply the perspective of decreasing the risk for chronic diseases.[14] Relating improved HRQOL to daily activities and tasks may be more appealing and help prompt overweight and obese individuals to participant in these weight loss interventions of combined diet and exercise.[14] Additionally, the overall success of these treatments can be defined beyond achieving an ideal weight.[3] Setting HRQOL as an important outcome may translate to enhanced motivation to make certain lifestyle changes.[3]

There are other clinical implications of improved HRQOL through diet and exercise. For example, discussing results of HRQOL assessments like the SF-36 can help to prompt conversation about the impact of body weight specifically on the way individuals live their lives.[3] Examining the impact of weight gain or loss on specific areas of HRQOL would allow clinicians and researchers to personalize the benefits of diet and exercise with weight loss interventions.[3] Ultimately, treatments and goals can be created that are unique to the individual and this may prove more successful for achieving improvements in HRQOL.[3] Results from these assessments may help practitioners and patients understand the full impact of obesity on a deeper level than increased risk for chronic diseases and this has the potential to influence the overall quality of care provided to this population.[3]

Summary

While it has been shown that combined interventions of diet and exercise improve dimensions of HRQOL as measured by the SF-36, one gap in the literature is that the factors that mediate this relationship are not well known. Many of the studies have investigated psychological improvements in variables such as self-efficacy, stress, and social support as possible mediators,[11,49] but the influence of physiological factors such as changes in fitness, body composition, and insulin, glucose, and cholesterol levels that may be associated with improvements in HRQOL have not been well investigated. Although fitness and weight loss have been investigated as possible mediators in several studies, conclusions are not consistent. Additionally, these physiological mediators have been investigated in specific clinical populations, but the research focusing on and including overweight and obese individuals without chronic conditions is far less prevalent.

The inconsistencies seen with improvements in fitness specifically, suggest a need for further investigation of CRF with reliable testing methods, as improvements in this area may influence the improvements seen in HRQOL. Secondly, the relationship between body composition changes for both lean and fat mass and improvements in SF-36 scores is important to investigate. With weight loss, individuals typically lose lean mass in addition to fat mass and preserving as much lean mass as possible should be a critical goal with these diet and exercise interventions.[21] Lastly, the potential association of HRQOL improvements with insulin, glucose, and cholesterol levels would provide beneficial knowledge especially to know if treating insulin resistance or other similar conditions in an individual may also help improve HRQOL. By controlling some of these metabolic levels, HRQOL could be improved among overweight or obese individuals.

When looking at the effects of exercise and weight loss on HRQOL in overweight and obese individuals, physical outcome measures including changes in fitness, body composition, weight loss, and cardiometabolic factors in relation to changes in SF-36 scores should be investigated. This knowledge is important in terms of developing treatment options for this population and establishing the best approach to interventions for improving HRQOL with diet and exercise. Due to the gap in literature and the importance of these physiological factors, the purpose of this study is to investigate changes in HRQOL using the SF-36 following a combined diet and aerobic exercise intervention and to determine the impact of mediators such as weight loss, lean mass, aerobic fitness, and insulin, glucose, and cholesterol changes on HRQOL.

Chapter III Methods:

The purpose of this study is to investigate the effects of a combined diet and aerobic exercise intervention on HRQOL and to assess the impact of potential physiological mediators on changes in HRQOL following the intervention. Data for this study was obtained from the Prescribed Exercise to Reduce Recidivism After Weight Loss pilot (PREVAIL-P) study. The primary purpose of the PREVAIL study was to evaluate the effect of aerobic exercise training amount on weight maintenance following clinically significant weight loss. The PREVAIL methodology was accepted, reviewed, and approved by the East Carolina University Institutional Review Board.

Participants

Thirty-six participants were recruited through emails sent to ECU employees, a PREVAIL study website, Facebook advertisements, and information at various forums held at Vidant Health. Eligible participants were both men and women, 30-65 years of age, and overweight or class 1 or class 2 obesity with a BMI of 25-40 kg/m^2. Exclusion criteria included diagnosis with type 1 or 2 diabetes or fasting glucose >125 mg/dL, cardiovascular disease or related disorders, systolic blood pressure >160 mm/Hg and diastolic blood pressure >100 mm/Hg, pregnant or planning to become pregnant, taking medications or have conditions that influence weight loss or regain, such as hypo/hyperthyroidism or bariatric surgery, and other medical conditions including respiratory, gastrointestinal, neuromuscular, neurological, HIV, or major psychiatric conditions. The participants also could not have any contraindications to exercise and must have been medication stable for 3 months prior to beginning the study with no changes in dosage or current medications.

Participant Screening

Figure 1 displays a flow chart of the schedule followed for screening and orientation visits. Initial screening for eligibility based on inclusion and exclusion criteria occurred by means of an online survey and telephone interview. If eligible, an orientation visit was then scheduled with study staff to further assess eligibility, discuss pertinent information about participation in the study, and answer any questions. At this first visit an informed consent was signed by every participant. Additional information was obtained from the participants including a medical history questionnaire and potential barriers for completing the study. Clinical measures of height, weight, and resting blood pressure were gathered. At the end of this visit, the participants were given an ActivPal accelerometer to wear for 7 consecutive days. Data collected from the accelerometer included steps taken, time spent sitting and standing, and the percentage of moderate and vigorous physical activity completed. After wearing the accelerometer following the orientation visit, participants returned for a comprehensive metabolic panel blood draw (hepatic, renal, hematological, endocrine, and metabolic function), which was reviewed by a physician for medical clearance. Once cleared, participants were scheduled for exercise sessions and for two outcome measure visits. At one clinical visit, the blood draw and SF-36 were completed and at the other visit, VO_2max testing and assessment of body composition were completed.

Baseline and Follow-Up Assessments

Measurements were taken at baseline and at 10 weeks, after the weight loss intervention. Figure 2 displays the assessment schedule for the different variables measured in the study. The assessments included weight, blood draw, a maximal exercise test to determine aerobic capacity, dual energy x-ray absorptiometry (DEXA) scan to assess fat mass and lean mass, and the SF-36 to assess HRQOL. For outcome measures, weight was recorded using a calibrated physician beam scale to the nearest tenth of kg with the participant wearing only a hospital gown. For exercise testing, a modified Balke treadmill (Trackmaster 425, Carefusion, Newton Kansas) protocol was used with respiratory gases (VO_2, VCO_2) and ventilation measured continuously using a True Max 2400 Metabolic Measurement Cart (Parvomedics, Salt Lake City, Utah) to determine CRF. A resting heart rate, blood pressure, and electrocardiogram (ECG) were recorded prior to beginning the test. For the first two minutes of the treadmill test, the speed remained at 2.0 mph with a 0% grade. The speed was then increased to 3.0 mph and the grade increased by 2.5% every 2 minutes until volitional fatigue was achieved. ECG reports from baseline exercise testing were cleared by a physician prior to participants beginning exercise sessions to further ensure there were no contraindications to exercise.

For body composition, DEXA scans were completed to calculate total fat mass, lean mass, and visceral fat. A Hologic Horizon A (Marlborough, MA) dual energy x-ray absorptiometer was used to perform a whole-body scan. For the scan, the participant was positioned on the table in the supine position with arms by the side, thumbs facing upward, and feet turned in a pigeon-toed position. The participant was instructed to remain still in this position for the duration of the scan. In addition to body composition, lipid, glucose, and insulin levels were measured through a blood draw, which was completed using standard analytical techniques and sent to LabCorp for analysis.

Lastly, the SF-36 was administered to participants via computer during one of the clinical visits. Optum's Smart Measurement System Patient-Reported Outcomes-Analytics (PRO Analytics) was used for administering the survey, as well as for collection of data. PRO Analytics is a standardized and scientifically valid platform that identifies patients at risk in realtime and measures population trends (OPTUM Inc. 2018, Eden Prarie, MN). The SF-36v2 was used. The surveys were scored instantaneously, and scores were reported for each subscale, as well as for the PCS and MCS. Group trends and risk stratification by physical and mental domains were also available. The results could be viewed in various formats such as the percentage of participants that scored the same or better, below, or well below compared to the general population of similar age and gender.

36-Item Short Form Health Survey

HRQOL has been commonly measured through two different approaches: specific instruments and generic instruments.[3] Generic instruments are not designed to assess HRQOL relative to a particular medical condition, but instead allow a generalized assessment, which provides the advantage of being administered to different populations and allows comparison across a variety of medical conditions.[3] The SF-36 is one of the most well-known generic instruments to evaluate HRQOL in obesity research and is widely used due to its brevity and comprehensiveness.[2] The SF-36 was developed for use in the Medical Outcomes Study [2] and is designed for self-administration, telephone administration, or administration during a personal interview. The Short Form 36 version 2 (SF-36v2) was made available for use in 1996 and although it is comparable to the original version, it serves as an updated and improved measurement tool.[2] The changes with this version include simpler instructions and questionnaire items, an improved layout, and greater comparability with widely used translations and cultural adaptations.[2] The assessment includes multi-item scales containing 2-10 items each, measuring HRQOL along 8 distinct domains: physical functioning, role limitations because of physical health problems, bodily pain, general health perception, vitality, social functioning, role limitations because of emotional problems, and general mental health including psychological distress and psychological well-being.[2] Two summary measures are also produced. The Physical Component Summary (PCS) correlates and is scored with the physical functioning, role limitations because of physical health problems, and bodily pain subscales, while the Mental Component Summary (MCS) is scored with the mental health, role limitations because of emotional problems, and social functioning subscales. The vitality, general health, and social functioning subscales correlate with both physical and mental components.[2] Scores are easy to compute and the assessment possesses good construct validity, high internal consistency, and high test-retest reliability.[2] All measures are typically scored on original scales of 0-100, with higher scores indicating better health.[5] Version 2.0 uses norm-based scoring algorithms for the 8 subscales, which consists of T-score transformation with mean (50) and standard deviation (10). This allows the scaled scores to be easily compared to US population norms.[2] It also allows for direct comparison among each of the scales without regard to the different floor and ceiling effects of the individual scales.[2] A between-groups difference of five points in individual SF-36 domains or two to three points in the overall physical and mental components is generally considered clinically significant.[2] In the context of exercise training, proposed minimal clinically important differences are 1.3 points for PCS and 2.0 points for MCS.[12]

Study Procedures

All assessments were completed at baseline and at 10 weeks, after completion of the weight loss intervention. The study procedures consisted of 3 parts: diet, lifestyle education classes, and aerobic exercise.

Diet

Participants were placed on an OPTIFAST diet, which is a medically supervised weight loss program consisting of lifestyle education and meal replacement products (i.e., shakes, bars, soups). All meal replacement products were provided by Vidant Wellness Center in Greenville, NC. OPTIFAST is a very low-calorie diet, which has participants consuming approximately 800 kcals per day. Other than the meal replacement products, the participants were to only consume some green leafy vegetables. The goal for participants during the 10 weeks was to achieve clinically significant weight loss of 7% or greater.

Lifestyle Education Classes

Participants also attended lifestyle educational classes once a week at Vidant Health, with one introduction class for the first week and one didactic class per week for the following 9 weeks. These were hour long sessions focused on topics such as goal setting, motivation, eating cues and triggers, mindful eating, relaxation techniques, cooking, and managing setbacks with weight loss. Figure 3 displays the didactic content covered during each class. At each of these sessions, participants were weighed and completed food intake questionnaires.

Aerobic Exercise

In addition to the OPTIFAST diet, participants came to East Carolina University (ECU) 2-3 times per week to complete supervised aerobic exercise training on the treadmill. The exercise was completed at moderate intensity, which was set at 50-75% VO_2max. The appropriate heart rate range for this intensity for each participant was determined from the baseline exercise test. The exercise amount was quantified in MET minutes, with the initial intensity level being 300 MET minutes per week and this amount was increased by 50 MET minutes until 700 MET minutes per week was reached. Figure 4 displays the exercise progression that was followed. At the beginning of each week, participants were weighed without shoes on a calibrated scale and weight was recorded to the nearest tenth of kg. On the first session of each week participants were also reminded to drink plenty of water and any changes in medications or physical activity level were recorded. Zephyr Bioharness 3 HR monitors (Medtronic Annapolis, MD) were used to record heart rate continuously throughout the sessions. The participant secured the strap directly on the skin and positioned below the inferior portion of the sternum, with the monitor on the left side of the body. After securing the heart rate monitor, the participant sat for 5 minutes and heart rate and blood pressure were recorded. Next, a 5-minute warmup was completed on the treadmill followed by immediately beginning the exercise session at a predetermined grade and speed and for a specified duration. Heart rate was kept within a specific range as determined from the baseline exercise test and the speed or grade of the treadmill was increased or decreased accordingly to keep heart rate within the correct range throughout the session. Heart rate and rating of perceived exertion (RPE) were recorded every 10 minutes throughout the session. The time was also recorded for when the exercise began and ended. Once the session was completed, the participant completed a cooldown on the treadmill and then sat down until heart rate returned to a resting value and a post exercise blood pressure was measured and recorded. Heart rate monitors were removed, and the exercise session was complete.

Following the session, mean exercise heart rate was calculated using OmniSense Analysis version 5.0 software (Medtronic, Annapolis, MD) (e.g., warm-up and cool-down were removed). Speed, grade, heart rate, and RPE for every 10 minutes of the session were entered into an Excel spreadsheet, which calculated mean heart rate and RPE, total energy expenditure, MET minutes exercised, total distance, and total exercise time. This data was entered into the study database on REDcap (Research Electronic Data Capture).

Statistical Analysis

All baseline participant characteristics were compiled. Quantitative data (age, weight, aerobic fitness, body composition, BMI, insulin, glucose, triglyceride, cholesterol levels, and HRQOL scores) is presented in means and standard deviations (SD). All categorical data (sex, race/ethnicity, menopausal status, depression medication) is presented as percentages. Paired T-tests were used to test the changes from pre to post in primary (e.g., HRQOL) and secondary (e.g., weight, lean and fat mass, aerobic fitness, insulin, glucose, cholesterol, etc.) outcome measures from baseline to follow-up. Change scores with corresponding 95% confidence intervals were computed. Independent samples T-tests were used to test for differences between baseline PCS and MCS scores among race (e.g., African American and Caucasian), sex (e.g., male and female) and menopausal status (e.g., pre vs post). Baseline correlations for the SF-36 domains were computed using Pearson correlations. This includes correlations between all SF-36 domains and age, body composition, fitness, weight, BMI, waist circumference, and insulin, glucose, triglyceride, and cholesterol levels. Pearson correlations were also computed to test correlations with changes in all SF-36 domains and the body composition and cardiometabolic levels tested. Additionally, Pearson correlations were used to test for associations in baseline SF-36 scores and changes in SF-36 domains. All SF-36 subscales were tested individually, as well as the changes in total SF-36 summary scores (e.g., MCS and PCS). A partial correlation was used to test associations in changes in HRQOL and body composition and cardiometabolic variables, while controlling for weight loss. To investigate the potential mediators in the response of changes in SF-36 scores, linear regression analysis was used. Predictor variables that were entered into the regression model for the MCS were age, changes in weight, baseline BMI, changes in lean mass, baseline lean mass, changes in fat mass, and baseline MCS score. The predictor variables entered into the linear regression model for the PCS were age, changes in weight, baseline BMI, changes in lean mass, baseline lean mass, changes in fat mass, baseline fat mass, and baseline PCS score. The significance level was set at $p<0.05$ for all analyses.

Chapter IV: Results

Baseline characteristics of the study participants (N=36) are displayed in Table 1. The sample had a mean (SD) age of 46.0 (11.0) years, mean weight of 94.8 (12.5) kg, and a mean BMI of 34.2 (3.4) kg/m^2. The sample was 80.6% female and 36.1% African American. Out of the female participants, 44.8% were postmenopausal. For overall HRQOL, the sample had a mean MCS score of 50.6 (8.9) and PCS score of 52.8 (7.4). With the norm-based scoring algorithm that was used, both of these baseline values are close to the average US general population scores of 50 points.[2] For HRQOL variables, the baseline SF-36 scores were not associated with any of the cardiometabolic, fitness, or body composition variables tested in this study (all ps>0.05). For example, baseline weight was not correlated with PCS (p=0.889) or MCS scores (p=0.599). Additionally, baseline MCS scores were not correlated with fat mass (p=0.299) or lean mass (0.961) and baseline PCS scores also were not associated with fat mass (p=0.530) or lean mass (0.830). Participant age was significantly correlated with baseline bodily pain scores (r=-0.34, p=0.041). There were no significant differences between MCS and PCS scores in Caucasian vs African American (p=0.505 and p=0.999), male vs female (p=0.729 and p=0.097), or pre-menopausal vs. postmenopausal women (p=0.601 and p=0.196).

Table 2 presents the mean changes in the outcome variables from the weight loss intervention. We observed a significant reduction in body weight with a range of 4.0 to 19.8 kg, with a percent weight loss of 9.3%. Additionally, there was a significant reduction in fat mass, overall body fat percentage, and lean mass (p<0.001). For cardiometabolic levels, we observed a significant decrease in total cholesterol (p<0.001), VLDL (p=0.001), LDL (p=0.006), and HDL (p=0.038). Similarly, there was a significant decrease in fasting insulin and glucose levels (p<0.001). For CRF, a significant increase was observed in relative fitness (p<0.001); however, no significant change was observed in absolute fitness (p>0.05).

As shown in Figure 5, there was a significant increase in all 8 domains of the SF-36 (p<0.05), with a range in mean change from 2.7 to 6.4 points. The largest increase was seen in the vitality domain (6.4 points, CI: 4.0 to 8.8 points). There were also significant increases in both mental (3.8 points, CI: 1.4 to 6.0) and physical (4.5 points, CI: 2.0 to 7.0) health summaries, as displayed in Figure 6. As shown in Table 4, changes in all SF-36 domains were significantly correlated with baseline scores in the corresponding domain.

Table 3A displays the significant negative correlations observed between improvements in some domains of HRQOL and changes in body composition and cardiometabolic levels. Change in weight was significantly correlated with changes in general health (r=-0.41, p=0.014), vitality (r=-0.42, p=0.012), and MCS (r=-0.35, p=0.037) scores. These three domains were also significantly correlated with changes in BMI: general health (r=-0.36, p=0.033), vitality (r=-0.46, p=0.004), and MCS (r=-0.41, p=0.015). Additionally, change in waist circumference was significantly correlated with changes in mental health (r=-0.37, p=0.029) and MCS (r=-0.38, p=0.027). For body composition, change in fat mass was correlated with vitality (r=-0.36, p=0.034) and MCS scores (r=-0.42, p=0.011) and lean mass changes were correlated with general health (r=-0.44, p=0.007), vitality (r=-0.35, p=0.039), and social functioning (r=-0.38, p=0.023). Figure 7 displays the scatter plots for correlations between HRQOL improvements and changes in lean and fat mass, while Figure 8 displays correlations between HRQOL improvements and weight loss. For metabolic levels as shown in table 3B, improvements in vitality were correlated with change in total cholesterol (r=-0.36, p=0.034) and change in LDL (r=-0.50, p=0.002), while improvements in general health were correlated with change in VLDL (r=-0.36, p=0.034) and triglycerides (r=-0.36, p=0.031). Figure 9 displays the scatter plots for correlations between vitality and LDL and total cholesterol. There were no significant correlations between improvements in HRQOL and changes in HDL, insulin, glucose, aerobic fitness, or age (all ps>0.05). When controlling for weight loss with a partial correlation, all correlations between HRQOL and body composition and cardiometabolic levels became nonsignificant, except vitality and LDL (r=0.42, p=0.012).

Linear regression analysis was used to test independent associations in change in SF-36 scores. As displayed in Table 5, baseline MCS scores and changes in fat mass were the main predictors of improvements in the MCS (model r^2=0.53). Improvements in PCS scores were mainly explained by baseline PCS scores (model r^2=0.79, ß=-0.890, p<0.001). Figure 10A displays the scatter plot for the linear regression model for the MCS and Figure 10B displays the scatter plot for the linear regression model for the PCS.

Chapter V: Discussion

The primary finding of the present study is that the intervention improved all domains of HRQOL, as measured by the SF-36. Secondly, improvements in several of the SF-36 domains were significantly correlated with changes in the body composition and cardiometabolic variables tested in this study. Further, our findings suggest that HRQOL among overweight and obese individuals may be improved following a combined intervention with weight loss and that these improvements may be associated with baseline scores, weight loss, a reduction in cholesterol, and changes in lean and fat mass. These findings have clinical implications for overweight and obese individuals, who often have decreased HRQOL compared to individuals of normal weight.[3-5] To our knowledge, this is the first study to investigate the association of improvements in various body composition and cardiometabolic variables (e.g., lean mass, fat mass, and cholesterol) with HRQOL following participation in the OPTIFAST weight loss diet and aerobic exercise. This study addresses a gap in the literature on the SF-36 with exercise and weight loss, as we observed that lean mass changes did not impact HRQOL improvements.

Following the intervention, improvements were observed in a variety of CVD (e.g., cholesterol, triglyceride, insulin, and glucose levels) risk factors and HRQOL. Similar to the findings of Fontaine et al.[15] and Imayama et al.[13], all 8 domains and the 2 summary measures of the SF-36 improved following 10 weeks of combined diet and aerobic exercise. Mean changes in HRQOL ranged from 2.7 to 6.4 points, with the greatest improvements seen in the role-emotional and vitality domains. According to the SF-36v2 manual, a change of 2 points for the PCS or 3 points for the MCS is defined as the clinically important difference for these summary measures.[2] There are many clinical implications of improved HRQOL, including decreased pain, more energy, better mood, and less work or daily activity problems. Improvements in the PCS specifically are associated with less physical limitations, improved well-being, and a higher rating of overall personal health, while improvements in the MCS typically indicate less psychological distress, fewer limitations in social activities, better overall life satisfaction, improved mood, and a higher energy level.[2] Ultimately, improved HRQOL may be associated with improved mortality.[58] The mean 3.8 point improvement on the MCS is associated with approximately a 7.6% decrease in all-cause mortality, while the mean 4.5 point improvement on the PCS is associated with an approximate 22.5% decrease in all-cause mortality.[58] We observed that the beneficial improvements in HRQOL did not appear to be limited by lean mass changes with weight loss. This suggests that weight loss with diet and exercise may be successful for improving HRQOL even when lean mass is lost during weight loss. To our knowledge, previous studies have not investigated the association between lean mass changes during weight loss programs and the potential effects on improvements in the SF-36.

Knowing the importance of improved HRQOL, it is necessary to understand the predictors of these improvements in an overweight and obese population in order to better develop treatment strategies and interventions. The present study observed that baseline levels of the SF-36 were highly correlated with the HRQOL improvements observed following the intervention. In addition, when testing independent associations in changes using linear regression, approximately 13% of the variance in improvements in the MCS was explained by changes in fat mass, while 40% was explained by baseline MCS scores. For the PCS, baseline PCS scores explained approximately 80% of the variance. This suggests that those individuals with lower HRQOL at baseline, may see the largest improvements following exercise and weight loss and this may help to identify those individuals who will benefit to a greater degree from improved HRQOL after weight loss and exercise. One limitation of this analysis is that the comparison of baseline and change scores could be affected by regression to the mean limitations.

A novel aspect of our study is that we investigated associations between body composition changes and HRQOL improvements (and not simply weight loss). Four of the SF-36 domains (general health, vitality, social functioning, and MCS) were significantly correlated with changes in fat mass or lean mass and change in fat mass explained approximately 13% of the change in MCS scores. Change in lean mass did not end up in any final linear regression model as a main predictor of HRQOL improvement. Even though there was a 6% reduction in lean mass with the OPTIFAST program, these reductions did not seem to inhibit HRQOL improvements. Although significant associations were found for body composition, when controlling for weight loss all correlations became nonsignificant which may indicate that weight loss is the primary contributor to improved HRQOL. One reason for the nonsignificant associations when controlling for weight loss could be that the benefits from the weight loss outweigh the potential impairments that may exist from losing lean mass. Overall weight loss and potentially fat mass appear to be more critical factors for improving HRQOL.

Similar to previous studies, we saw correlations between weight loss and HRQOL. There was a mean clinically significant weight loss of 9.3% among the participants and this was associated with the HRQOL domains of general health, vitality, and the MCS. These domains have commonly shown correlations with weight loss in previous literature.[13,15,18] For example, Imayama et al.[13] demonstrated correlations with improved vitality, mental health, physical functioning, and role physical domains, Ross et al.[18] found correlations with all domains except role physical and role emotional, and Fontaine et al.[15] found associations with physical functioning, role-physical, general health, mental health, and vitality domains. Also as seen in previous literature, the other correlations between improvements in the SF-36 and changes in the variables measured in this study were varying. The five main HRQOL domains with significant correlations were the general health, vitality, mental health, social functioning, and MCS domains. In addition to weight loss and body composition changes of lean and fat mass, these domains were associated with various cardiometabolic variables such as change in cholesterol and triglyceride levels. One outlier was evaluated for the analysis of HRQOL correlations for a larger change in some variables measured. When this datapoint was removed, there were no major effects on our findings (data not shown).

In addition to improvements in all HRQOL domains, improvements in CVD risk factors were observed; however, these changes may not be connected. In the present study only the domains of general health and vitality were associated with triglyceride and cholesterol changes. Although significant correlations were initially found, all correlations became nonsignificant when controlling for weight loss except the association of improved vitality and LDL, indicating that weight loss may be the main predictor of these improvements. The association of LDL and vitality even when controlling for weight loss has not been confirmed in previous literature. We were unable to determine whether this association was truly independent of weight loss, so further research is needed to clarify this relationship. We did not find significant associations between improvements in insulin and glucose and any of the SF-36 domains. As with cholesterol, the overall weight loss that was achieved is likely a stronger contributor to the improved HRQOL following combined interventions.

Although improvements in relative fitness were observed, neither absolute nor relative fitness were significantly correlated with improvements in HRQOL. Literature on the association with improvements in aerobic fitness is conflicting, but our findings are supported by Martin et al.[16] and Svensson et al.[12], who found no associations. One difference seen in several studies that found significant correlations is that these studies were much longer (e.g., 6-12 months) compared to the 10-week intervention of the present study.[11,13] Thus, there was a greater length of exposure to aerobic activity which may represent an important aspect in terms of significantly increasing aerobic fitness.

Although improvements were seen in all domains of the SF-36, we found a greater number of significant associations between body composition and cardiometabolic variables and the domain of vitality than for the more physical domains, such as physical functioning. The physical functioning domain measures limitations in daily activities such as walking specified distances, carrying groceries, and bathing or dressing, while the vitality domain asks about overall energy level and amount of fatigue experienced. Less fatigue and increased energy may be more likely to be perceived as improvements following the combined intervention with weight loss. Additionally, since we excluded individuals with a BMI classified as class 3 obesity and part of the inclusion criteria involved being able to fully participate in exercise, our participants may not have had extreme physical limitations that significantly interfered with their daily activities. Also, mean baseline PCS scores were above the population average of 50 (i.e., 52.8 points) and mean physical functioning scores were slightly above the population average at 50.9 points. These higher baseline physical scores likely had an influence on the changes and associations that were observed.

There are several public health implications for the findings of this study. Ultimately, improved HRQOL is associated with decreases in all-cause mortality.[58] Since all domains of HRQOL significantly improved following the combined OPTIFAST weight loss program and aerobic exercise intervention, it may be beneficial to use HRQOL as a main goal of such interventions. The combined weight loss and exercise intervention improved CVD risk factors improved, while also improving HRQOL. These findings demonstrate the importance of diet and exercise beyond chronic disease treatment and prevention.[14] Promoting improved HRQOL and relating these improvements to individuals' daily activities may serve as better motivation for adopting these lifestyle interventions of diet and exercise with weight loss. The incentive of improved HRQOL may motive overweight and obese individuals to participate in diet and exercise interventions to lose weight.

The present study possesses several strengths. First, the sample was diverse, consisting of 36% African American. Secondly, all exercise sessions were supervised training sessions where heart rate and RPE were monitored. The amount of exercise that each participant completed throughout the study was strictly monitored and tracked each week. Additionally, the diet consisted of OPTIFAST, which is a medically supervised weight loss program, which enhances the clinical relevance of the study. Clinically significant weight loss was achieved by the participants, which makes the weight loss range generalizable for overweight/obese individuals. Lastly, the SF-36v2 was used to assess HRQOL and this survey has been validated and widely used in obesity research.[2]

This study also has several limitations. First, there are limitations regarding the sample used in the study. For example, there was an underrepresentation of men with 80.6% of the sample being female. According to BMI, the sample also consisted of only 4 individuals classified as overweight (BMI 25-29.9 kg/m^2), while 32 were considered obese (BMI>30 kg/m^2). Individuals above class II obesity were excluded from the study, so the findings are not generalizable to those of a higher BMI class. Age is also a limitation, as we cannot make conclusions about individuals over age 65. Additionally, we had participants spanning a relatively large age group (30-65 years) so the findings of HRQOL improvements and various associations may have been different depending on the participant's age. For example, an individual in their early 30s may perceive HRQOL improvements in a different way than an individual in the 60-65 age range. We did not analyze participants separately based on age; However, since HRQOL may differ between age groups (i.e., 18-36 and 65+), future research should investigate the impact of age on improved HRQOL following a weight loss and aerobic exercise intervention. Another limitation is that the OPTIFAST diet may have increased lean mass loss due to the fast weight loss, compared to other programs where weight loss is slower over time.[59] It is also important to note that the data was gathered from a weight maintenance study, for which getting participants to clinically significant weight loss was the first component of the study. Since the data for the present study came from the weight loss component of that study, there is not a control group to serve as a comparison group.

In conclusion, a combined OPTIFAST weight loss and aerobic exercise training program may lead to improvements in HRQOL, which may be dependent upon baseline HRQOL levels and weight loss. Novel findings indicate that lean mass reductions with the OPTIFAST diet did not appear to inhibit HRQOL improvements. The public health implications of these findings include knowledge to develop specific treatments and interventions for effectively improving HRQOL and also identifying those individuals who will benefit the greatest from these interventions to improve HRQOL. Future studies should investigate the impact of exercise on HRQOL during weight maintenance, the influence of strength training on improved HRQOL, and sex, racial, or age differences on predictors of HRQOL improvements.

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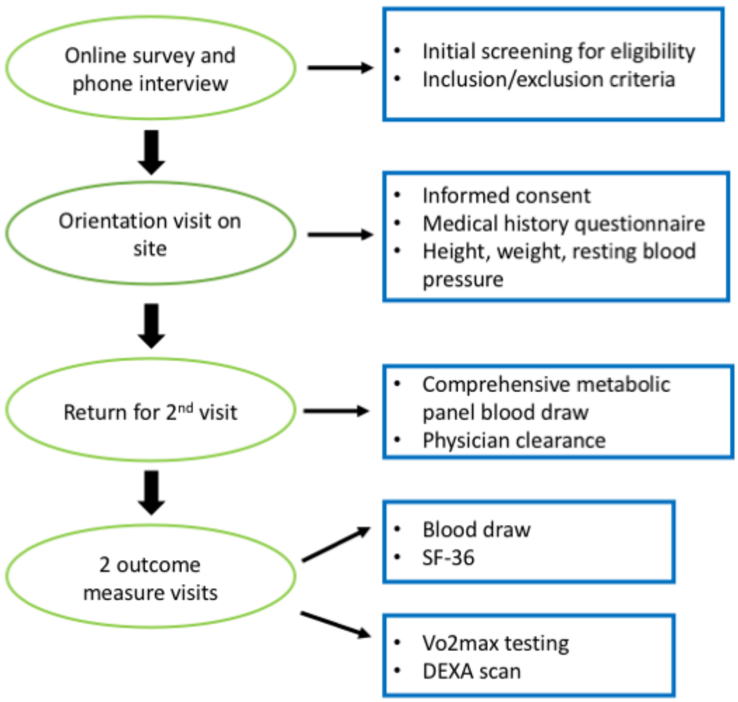
Tables and Figures



<u>Figure 1:</u> Flow chart displaying participant screening and orientation visits

Variable	Test/Assessment	Baseline	Follow-Up
Weight (kg)	Calibrated physical beam scale	X	X
Body Composition	DEXA	X	X
Cardiometabolic Levels (lipids, insulin, glucose)	Blood draw sent to LabCorp	X	X
Aerobic fitness	Modified Balke treadmill test with metabolic cart	X	X
HRQOL	SF-36v2	X	X

Figure 2: Assessment schedule for baseline and follow up measures

DIDACTIC CONTENT FOR OPTIFAST CLASS SCHEDULE	
WEEK 1	Product Info/Program Logistics/Goal Setting – RD & Behaviorist
WEEK 2	Motivation to Change - Behaviorist
WEEK 3	Importance of Self-Monitoring - RD
WEEK 4	Exercise Update – Exercise Specialist
WEEK 5	Identifying Eating Cues, Triggers, and Eating Style? - RD
WEEK 6	Where are the calories? / Food Label Reading - RD
WEEK 7	Mindful Eating/Emotional Eating - Behaviorists
WEEK 8	Relaxation Techniques – Mind Body Staff
WEEK 9	Eating Out/Special Occasions/Cooking Quick and Lite - RD
WEEK 10	Effects of Stress on Body Weight - Behaviorist

Figure 3: Didactic content for OPTIFAST lifestyle education classes at Vidant

	Exercise amount
Week 1	300 MET min.
Week 2	350 MET min.
Week 3	400 MET min
Week 4	450 MET min.
Week 5	500 MET min.
Week 6	550 MET min.
Week 7	600 MET min.
Week 8	650 MET min.
Week 9-10	700 MET min.

Figure 4: Aerobic exercise progression from week 1 to week 10

Variable	Mean (SD)
Age (yrs.)	46.0 (11.0)
Sex	
Female % (n)	80.6% (29)
Postmenopausal % (n)	44.8% (13.0)
Ethnicity	
Caucasian % (n)	55.6% (20.0)
African American % (n)	36.1% (13.0)
Asian % (n)	0.03% (1.0)
American Indian or Alaskan Native % (n)	0.03% (1.0)
Mixed Race % (n)	0.03% (1.0)
Depression Medication % (n)	0.8% (3.0)
Weight (kg)	94.8 (12.5)
BMI (kg/m^2)	34.2 (3.4)
Waist Circumference (cm)	97.9 (9.4)
Lean Mass (g)	53852.0 (10817.0)
Fat Mass (g)	39447.2 (6017.1)
Body Fat (%)	41.5% (5.7%)
VO_2peak (L/min)	2.03 (0.50)
VO_2peak (ml/kg/min)	21.4 (4.1)
Glucose (mg/dL)	96.3 (9.7)
Insulin (ulU/mL)	17.8 (10.7)
Total Cholesterol (mg/dL)	186.9 (30.2)
VLDL (mg/dL)	21.5 (11.0)
LDL (mg/dL)	112.9 (27.4)
HDL (mg/dL)	52.5 (12.8)
Triglycerides (mg/dL)	107.1 (54.9)
HRQOL SF-36 Scores	
Domain	**Mean (SD)**
General Health	54.2 (5.9)
Bodily Pain	53.6 (7.4)
Vitality	50.4 (8.5)
Social Functioning	50.8 (8.0)
Mental Health	52.8 (7.5)
Physical Functioning	50.9 (7.6)
Role-Emotional	49.0 (8.5)
Role-Physical	52.6 (7.3)
Mental Health Summary	50.6 (8.9)
Physical Health Summary	52.8 (7.4)

Table 1: Baseline participant characteristics. Continuous variables are displayed in mean (SD) and categorical variables are summarized in (%) n. BMI: Body Mass Index, VO2peak: Maximal oxygen consumption, VLDL: Very low-density lipoprotein, LDL: Low density lipoprotein, HDL: High density lipoprotein.

Variable	Mean Change	95% CI Lower	95% CI Upper	p-value
Weight (kg)	-8.8	-9.9	-7.7	<0.001
BMI (kg/m^2)	-3.2	-3.5	-2.8	<0.001
Waist Circumference (cm)	-8.4	-10.1	-6.7	<0.001
Lean Mass (g)	-3327.0	-4074.6	-2579.4	<0.001
Fat Mass (g)	-5419.1	-6168.1	-4670.1	<0.001
Body Fat (%)	-2.1	-2.7	-1.5	<0.001
VO_2peak (L/min)	0.02	-0.03	0.07	0.358
VO_2peak (ml/kg/min)	2.4	1.9	3.0	<0.001
Glucose (mg/dL)	-11.3	-14.0	-8.6	<0.001
Insulin (ulU/mL)	-8.8	-13.2	-4.3	<0.001
Total Cholesterol (mg/dL)	-15.1	-21.6	-8.6	<0.001
VLDL (mg/dL)	-4.8	-7.5	-2.2	0.001
LDL (mg/dL)	-7.9	-13.3	-2.4	0.006
HDL (mg/dL)	-2.4	-4.7	-0.1	0.038
Triglycerides (mg/dL)	-23.7	-37.0	-10.4	0.001

Table 2: Change scores from baseline to 10-week follow up. Presented as mean change with 95% confidence intervals. BMI: Body Mass Index, VO2peak: Maximal oxygen consumption, VLDL: Very low-density lipoprotein, LDL: Low density lipoprotein, HDL: High density lipoprotein.

	Δ Weight		Δ BMI		Δ Waist circumference		Δ Fat Mass		Δ Lean Mass		Δ Absolute Fitness		Δ Relative Fitness	
	r	p	r	p	r	p	r	p	r	p	r	p		
Δ General Health	**-0.41**	**0.014**	**-0.36**	**0.033**	-0.08	0.670	-0.18	0.291	**-0.44**	**0.007**	-0.15	0.377	0.12	0.472
Δ Vitality	**-0.42**	**0.012**	**-0.46**	**0.004**	-0.30	0.076	**-0.36**	**0.034**	**-0.36**	**0.039**	-0.25	0.135	0.04	0.841
Δ Social Functioning	-0.32	0.057	-0.30	0.072	-0.16	0.349	-0.23	0.176	**-0.38**	**0.023**	-0.12	0.506	0.16	0.351
Δ Mental Health	-0.31	0.070	-0.31	0.068	**-0.37**	**0.029**	-0.30	0.074	-0.16	0.340	-0.16	0.350	0.02	0.901
Δ Physical Functioning	-0.15	0.398	-0.09	0.621	-0.07	0.700	0.04	0.815	-0.30	0.080	-0.18	0.307	-0.13	0.461
Δ Bodily Pain	-0.20	0.236	-0.21	0.229	0.04	0.826	-0.10	0.567	-0.22	0.204	-0.06	0.722	0.01	0.965
Δ Role Emotional	0.01	0.935	-0.36	0.835	-0.05	0.791	-0.07	0.686	-0.03	0.865	0.18	0.287	0.28	0.097
Δ Role Physical	-0.17	0.328	-0.08	0.661	0.168	0.336	-0.01	0.934	-0.22	0.191	0.11	0.523	0.18	0.290
Δ MCS	**-0.35**	**0.037**	**-0.40**	**0.015**	**-0.38**	**0.027**	**-0.42**	**0.011**	-0.19	0.263	-0.04	0.832	0.27	0.112
Δ PCS	-0.22	0.191	-0.16	0.352	0.10	0.552	-0.03	0.877	-0.30	0.073	-0.04	0.797	0.05	0.781

Table 3A: Pearson correlations between weight loss, improvements in fitness, decreased BMI, waist circumference, fat mass, lean mass, and improvements in HRQOL.

	Δ Triglycerides		Δ LDL		Δ VLDL		Δ HDL		Δ Total cholesterol		Δ Insulin		Δ Glucose	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Δ General Health	**-0.36**	**0.031**	-0.17	0.326	**-0.36**	**0.034**	0.08	0.633	-0.26	0.127	-0.03	0.851	-0.08	0.652
Δ Vitality	0.26	0.122	**-0.50**	**0.002**	0.26	0.127	-0.10	0.550	**-0.36**	**0.034**	-0.12	0.481	-0.17	0.321
Δ Social Functioning	0.15	0.396	-0.25	0.146	0.15	0.389	0.09	0.597	-0.12	0.501	-0.05	0.756	0.01	0.973
Δ Mental Health	0.20	0.253	-0.17	0.329	0.19	0.275	0.16	0.341	-0.01	0.969	-0.20	0.235	-0.18	0.294
Δ Physical Functioning	-0.27	0.110	0.01	0.949	-0.26	0.125	0.10	0.548	-0.06	0.722	-0.10	0.581	-0.06	0.736
Δ Bodily Pain	-0.13	0.450	-0.20	0.253	-0.13	0.462	-0.07	0.705	-0.24	0.158	-0.16	0.345	-0.07	0.685
Δ Role Emotional	0.023	0.868	-0.14	0.401	0.05	0.792	0.23	0.188	-0.02	0.889	0.28	0.105	0.06	0.746
Δ Role Physical	-0.14	0.420	-0.14	0.424	-0.13	0.460	0.17	0.313	-0.12	0.533	-0.04	0.816	0.06	0.721
Δ MCS	0.23	0.173	-0.29	0.087	0.23	0.181	0.11	0.517	-0.11	0.518	0.03	0.862	-0.06	0.747
Δ PCS	-0.33	0.051	-0.03	0.871	-0.32	0.057	-0.00	0.990	-0.16	0.364	-0.13	0.459	0.05	0.775

Table 3B: Pearson correlations between changes in metabolic levels and improvements in HRQOL.

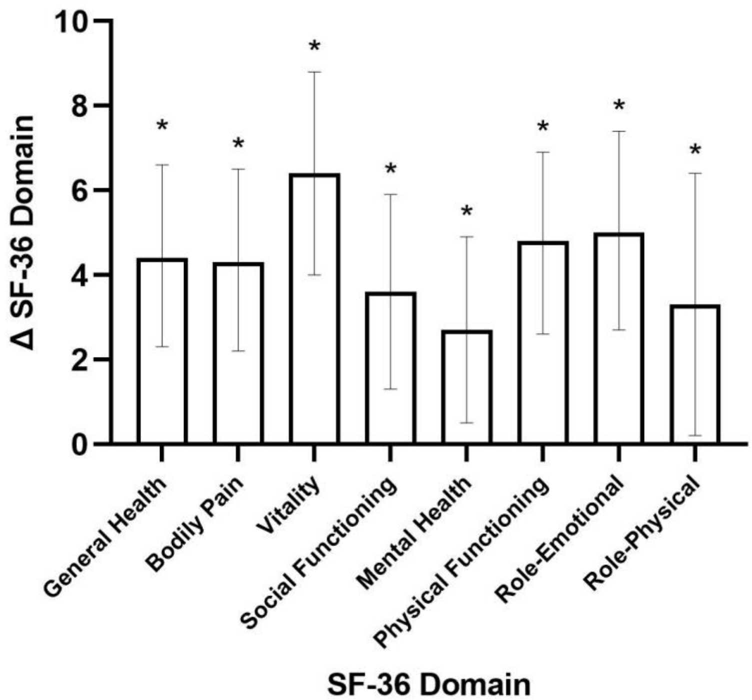


Figure 5: Mean changes with 95% CI for the 8 domains of the SF-36 after the weight loss intervention

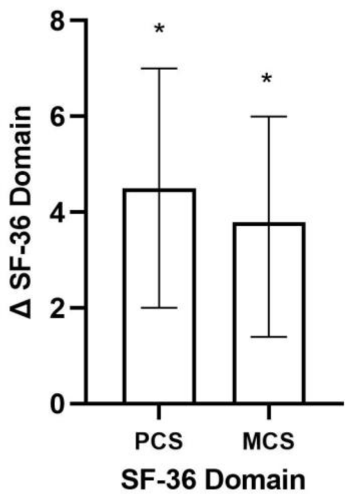


Figure 6: Mean changes with 95% CI for the physical and mental component summaries of the SF-36

SF-36 Domain	r	p
General Health	-0.48	0.003
Bodily Pain	-0.77	<0.001
Vitality	-0.54	0.001
Social Functioning	-0.77	<0.001
Mental Health	-0.46	0.004
Role Emotional	-0.82	<0.001
Role Physical	-0.86	<0.001
Physical Functioning	-0.95	<0.001
PCS	-0.89	<0.001
MCS	-0.63	<0.001

Table 4: Pearson correlations between baseline and change scores for the 8 SF-36 domains and 2 summary measures

Variable MCS	Standardized Coefficient ß	T value	Variable r^2	p-value
Baseline MCS	-0.600	-5.030	0.40	<0.001
Δ Fat Mass (g)	-0.368	-3.085	0.13	0.004
Variable PCS	**Standardized Coefficient ß**	**T value**	**Variable r^2**	**p-value**
Baseline PCS	-0.890	-11.358	0.79	<0.001

Table 5: Linear regression analysis for change in the SF-36 MCS and PCS. For the MCS, the total r^2 for the model is 0.534 and the adjusted r^2 is 0.506. For the PCS, the total r2 for the model is 0.791 and the adjusted r2 is 0.785.

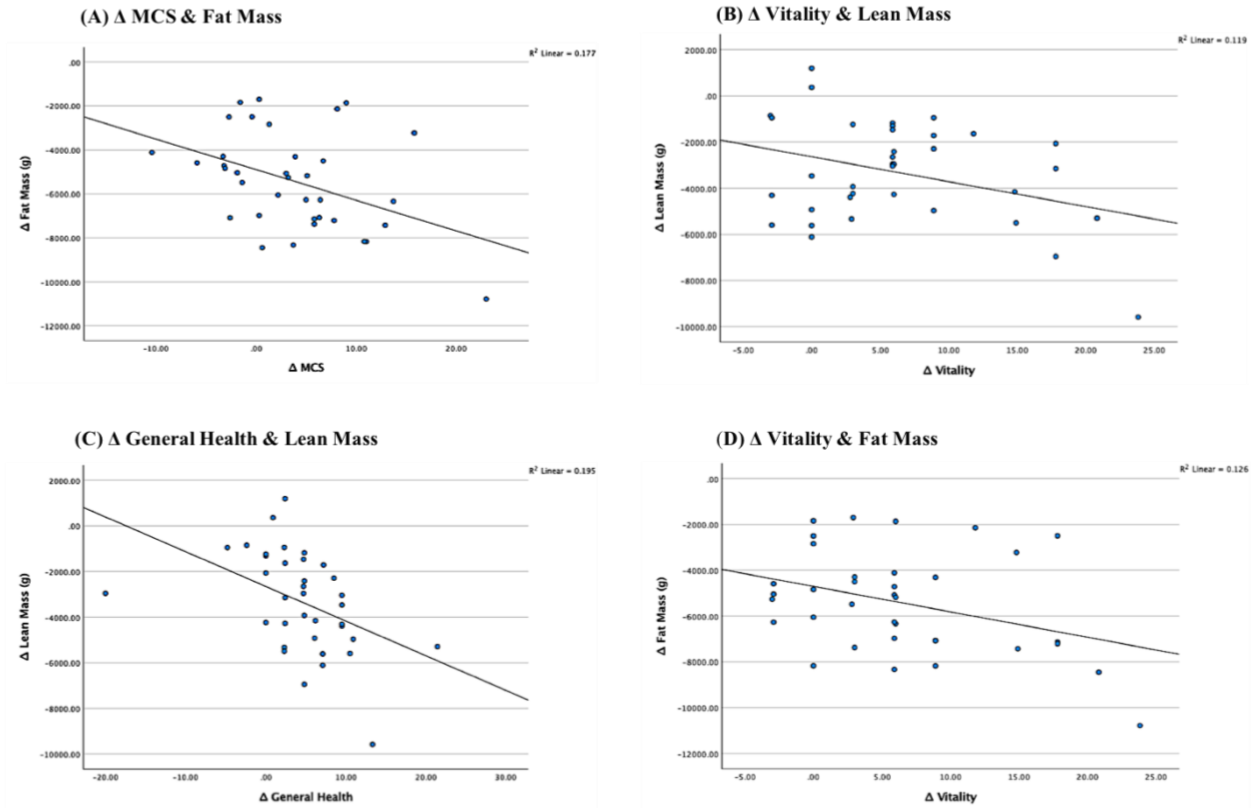
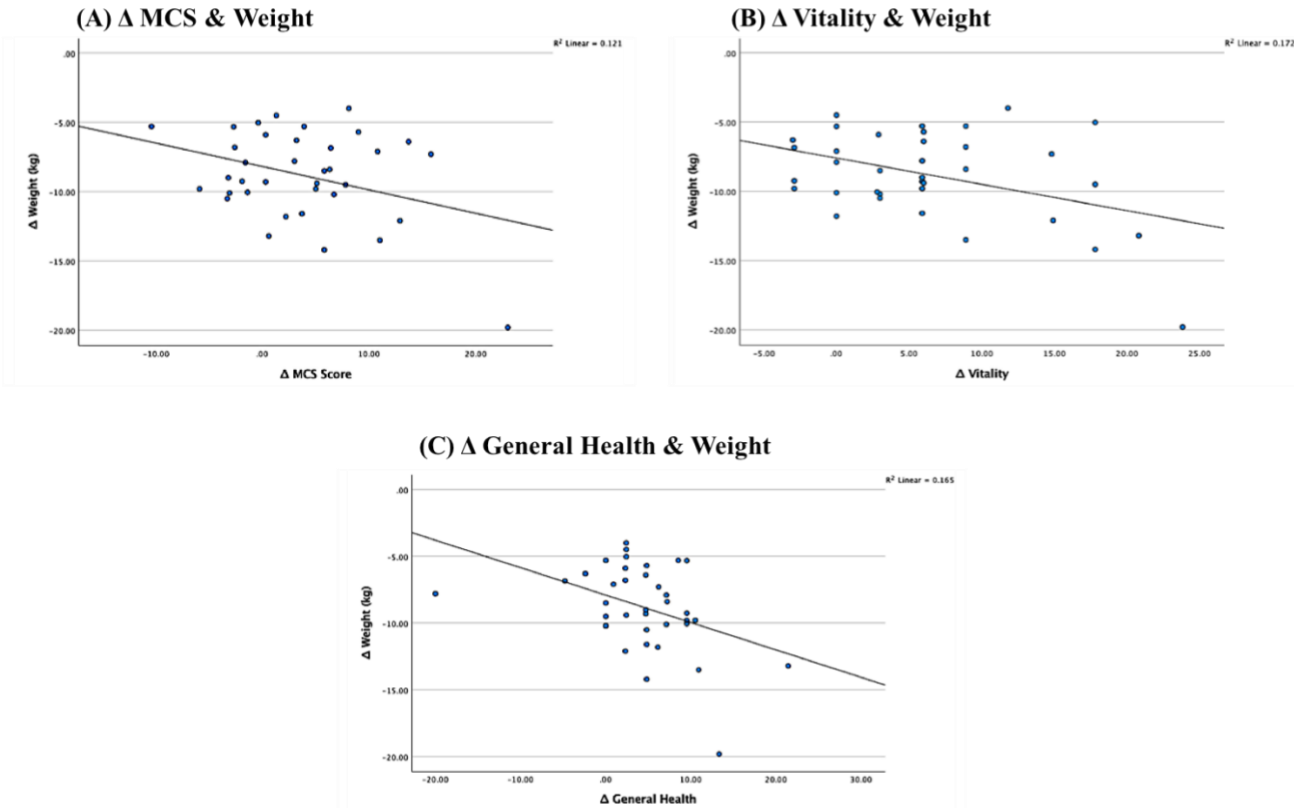
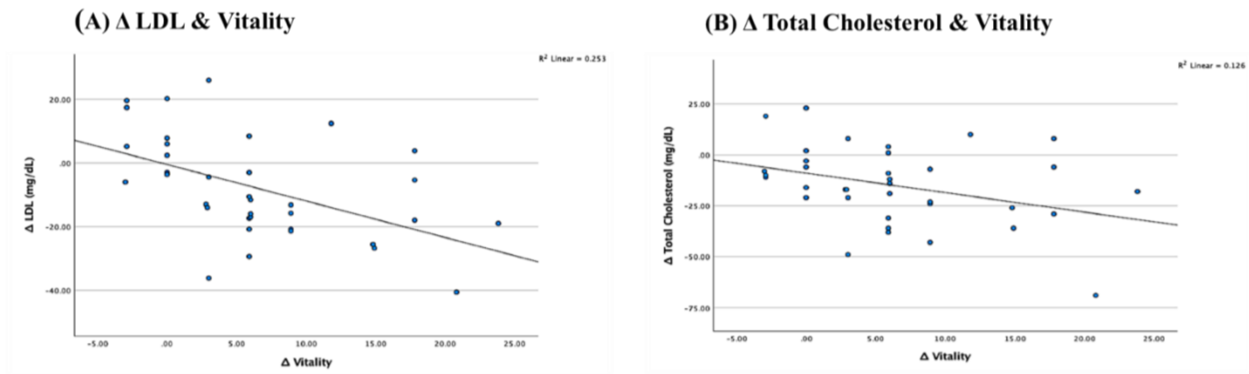


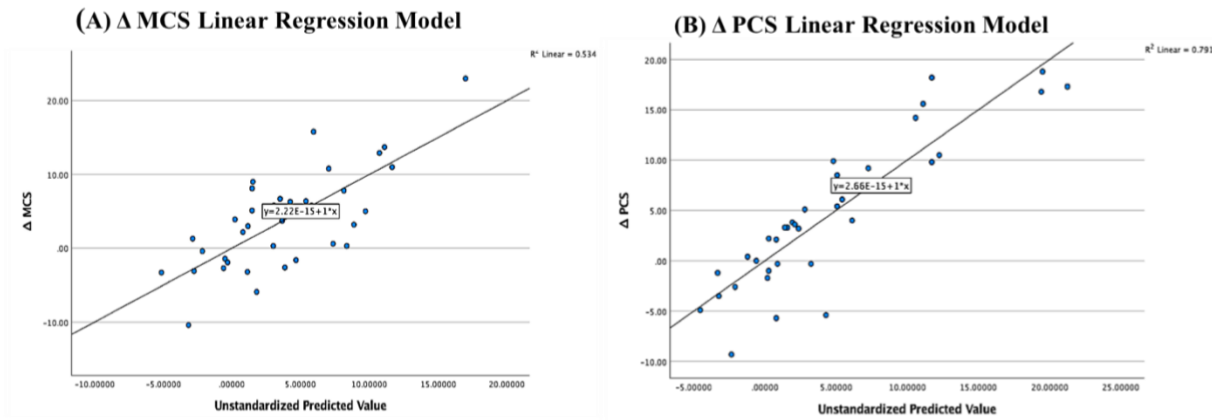
Figure 7: Scatter plots displaying correlations between body composition changes and HRQOL improvements. (A) MCS and fat mass, r^2=0.18 (B) vitality and lean mass, r^2=0.12 (C) general health and lean mass, r^2=0.19 (D) vitality and fat mass, r^2=0.13



<u>Figure 8:</u> Scatter plots displaying correlations between changes in weight and improvements in HRQOL. (A) MCS and weight, $r^{2=}$0.12 (B) vitality and weight, r^2=0.17. (C) general health and weight, r^2=0.17



<u>Figure 9:</u> Scatter plots displaying correlations between changes in metabolic levels and improvements in HRQOL. (A) vitality and LDL, r^2=0.25 (B) vitality and total cholesterol, r^2=0.13



<u>Figure 10:</u> Scatter plot displaying the linear regression models for (A) Δ MCS where Δ fat mass r^2=0.13 and baseline scores r^2= 0.40 (B) Δ PCS where baseline PCS scores r^2=0.79

Appendix: IRB Approval Letter

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** ·
rede.ecu.edu/umcirb/

Notification of Continuing Review Approval: Expedited

From: Biomedical IRB
To: Damon Swift
CC:

Anna Huff
Date: 10/26/2020
Re: CR00008847
UMCIRB 18-001904
PREVAIL-P

The continuing review of your expedited study was approved. Approval of the study and any consent form(s) is for the period of 10/19/2020 to 10/18/2021. This research study is eligible for review under expedited category # 8c. The Chairperson (or designee) deemed this study no more than minimal risk.

As the Principal Investigator you are explicitly responsible for the conduct of all aspects of this study and must adhere to all reporting requirements for the study. Your responsibilities include but are not limited to:

1. Ensuring changes to the approved research (including the UMCIRB approved consent document) are only initiated with UMCIRB review and approval except when necessary to eliminate an apparent immediate hazard to the participant. All changes (e.g. a change in procedure, number of participants, personnel, study locations, new recruitment materials, study instruments, etc.) must be prospectively reviewed and approved by the UMCIRB before they are implemented;

2. Ensuring that only valid versions of the UMCIRB approved, date-stamped informed consent document(s) are used for obtaining informed consent (consent documents with the IRB approval date stamp are found under the Documents tab in the ePIRATE study workspace);

3. Promptly reporting to the UMCIRB all unanticipated problems involving risks to participants and others;

4. Applying for continuing review and receive approval of continuation of the study prior to the study's current expiration date. Application for continuing review should be submitted no less than 30 days prior to the expiration date. Lapses in approval (i.e. study expiration) should be avoided to protect the safety and welfare of enrolled participants and liability to the University; and

5. Submission of a final report when the study meets the UMCIRB criteria for closure. Study approval should not be allowed to expire simply because the study is completed, rather the UMCIRB should be formally notified of study completion via the final report process.

The approval includes the following items:

Document	Description
Compensatory Health Beliefs Scale.doc(0.01)	Surveys and Questionnaires
compensatory health beliefs scale.pdf(0.01)	Surveys and Questionnaires
Dr. Swift's letter of intent for IRB review.pdf(0.01)	Additional Items
Food Cravings Questionnaire-State(0.02)	Surveys and Questionnaires
Food frequency Questionnaire(0.01)	Surveys and Questionnaires
Food-Craving Inventory(0.03)	Surveys and Questionnaires
Light Scanner Protocol(0.01)	Study Protocol or Grant Application
PDF of study website(0.01)	Recruitment Documents/Scripts
PREVAIL-EMAIL recruitment (0.01)	Recruitment Documents/Scripts
PREVAIL-P Consent Study 1-Clean(0.04)	Consent Forms
PREVAIL-P-Consent-Study-2-Clean(0.01)	Consent Forms
Retrospective VAS(1).docx(0.01)	Surveys and Questionnaires
SF-36(0.01)	Surveys and Questionnaires
Study 1- Recruitment(0.03)	Recruitment Documents/Scripts
Study 2 Flyer (0.03)	Recruitment Documents/Scripts
Study protocol (0.04)	Study Protocol or Grant Application
Three Factor Eating Questionnaire(0.02)	Surveys and Questionnaires
Web-screener(0.01)	Recruitment Documents/Scripts
Weight Efficacy Life-Style Questionnaire (0.02)	Surveys and Questionnaires
Weight Stigma questionnaire(0.02)	Surveys and Questionnaires

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

East Carolina University

Hello, Damon Swift

You Are Here: PREVAIL-P

Reading: UMCIRB 18-001904

Go to forms menu Print Help

Study Identification Information

This is the first step in your Human Research Application. You will automatically be guided to the appropriate page views needed to complete your submission. If a question is not applicable to your study, you may state this as your response. Please read the help text located on the right side of the page throughout this application.

1.0 * **Study Name (Short):**
PREVAIL-P

The short study name is limited to 255 characters.

2.0 **Study Name (Long):**
Prescribed Exercise to Reduce Recidivism After Weight Loss

Most other text boxes do not have any limits on number of characters.

3.0 * **Summary of Research in Lay Terms:**
The Prescribed Exercise to Reduce Recidivism After Weight Loss pilot (PREVAIL-P) study will evaluate the effect of aerobic exercise training amount on weight maintenance following after a significant weight loss. Study participants will lose about 7-10% of their body weight and be assigned to exercise at physical activity guidelines or weight maintenance guidelines.

The lay summary should be no more than 400 words and should include the following:
Background/Purpose of Study
Description of Subjects/Participants
Research Methods/Procedures

4.0 * **Principal Investigator:**
Damon Swift

Use the "select" or "add" button to choose from a list of individuals for each applicable role.

5.0 **Faculty Investigator** (Serving as the responsible individual in the oversight of the research study when the PI is a student, resident, fellow or visiting faculty.)

Faculty Investigator IRB Certification Renewal Deadline:

6.0 **Study Coordinator or Contact Individual:**
Anna Huff

7.0 **Contact Individual(s) (if different from Study Coordinator or Principal Investigator):**

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline

There are no items to display

*People added here **will** be able to **edit** the study.*

Clicking the "Add" button allows you to choose individuals that are already registered within ePIRATE. This function will not add individuals that have not registered in ePIRATE yet.

8.0 **Sub-Investigators:**

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline
Anderson	Brianna	Kinesiology, Department of	Brianna Anderson's Profile	3/31/2022

☰ Compare «

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline
Barefoot	Savanna	Kinesiology, Department of	Savanna Barefoot's Profile	[illegible]9/2023
Bartlett	Allison	Kinesiology, Department of	Allison Bartlett's Profile	7/18/2022
Beyl	Robbie	Other Organization/Institution	Robbie Beyl's Profile	9/20/2021
Boone	Paige	Kinesiology, Department of	Paige Boone's Profile	9/5/2022
Brophy	Patricia	East Carolina Diabetes and Obesity Institute (ECDOI)	Patricia Brophy's Profile	3/20/2022
Brown	Taylor	Kinesiology, Department of	Taylor Brown's Profile	9/21/2021
Carels	Robert	Psychology, Department of	Robert Carels's Profile	7/18/2023
Charlton	Sarah	Kinesiology, Department of	Sarah Charlton's Profile	8/21/2022
Clark	Angela	East Carolina Diabetes and Obesity Institute (ECDOI)	Angela Clark's Profile	7/12/2021
Davis	Emily	Kinesiology, Department of	Emily Davis's Profile	1/12/2022
Dubis	Gabriel	East Carolina Diabetes and Obesity Institute (ECDOI)	Gabriel Dubis's Profile	8/27/2023
Feffer	Andrew	Kinesiology, Department of	Andrew Feffer's Profile	1/17/2022
Garner	Zoe	Kinesiology, Department of	Zoe Garner's Profile	1/13/2023
Gosney	Ryan	Kinesiology, Department of	Ryan Gosney's Profile	1/11/2023
Grammer	Emily	Kinesiology, Department of	Emily Grammer's Profile	7/2/2023
Hearne	Joshua	Kinesiology, Department of	Joshua Hearne's Profile	7/20/2022
Hiller	Kayleigh	Kinesiology, Department of	Kayleigh Hiller's Profile	7/23/2022
Holland	Kyle	Kinesiology, Department of	Kyle Holland's Profile	1/5/2023
Holsinger	Jourdyn	Kinesiology, Department of	Jourdyn Holsinger's Profile	7/15/2021
Houmard	Joseph	Kinesiology, Department of	Joseph Houmard's Profile	5/1/2023
Howell	Harrison	Kinesiology, Department of	Harrison Howell's Profile	8/12/2022