Effects of aerobic and resistance exercise on health-related quality of life in inactive adults with elevated blood pressure

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Effects of aerobic and resistance exercise on health-related quality of life in inactive adults with elevated blood pressure

by

Heather Rose Danzer

A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of
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Program of Study Committee:
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>NOMENCLATURE</td>
<td>vii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td><strong>CHAPTER 1: INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>CHAPTER 2: REVIEW OF LITERATURE</strong></td>
<td>5</td>
</tr>
<tr>
<td>Health-Related Quality of Life</td>
<td>5</td>
</tr>
<tr>
<td>As a Predictive Measure</td>
<td>8</td>
</tr>
<tr>
<td>HRQoL in Randomized Controlled Trials</td>
<td>12</td>
</tr>
<tr>
<td>Physical Activity Guidelines</td>
<td>18</td>
</tr>
<tr>
<td>Barriers to Exercise</td>
<td>18</td>
</tr>
<tr>
<td>Importance of Fitness</td>
<td>19</td>
</tr>
<tr>
<td>Conclusion</td>
<td>22</td>
</tr>
<tr>
<td><strong>CHAPTER 3: METHODOLOGY</strong></td>
<td>24</td>
</tr>
<tr>
<td>Participants</td>
<td>24</td>
</tr>
<tr>
<td>Procedures</td>
<td>24</td>
</tr>
<tr>
<td>Phone Screening</td>
<td>24</td>
</tr>
<tr>
<td>Orientation and Education Sessions</td>
<td>25</td>
</tr>
<tr>
<td>Assessments</td>
<td>26</td>
</tr>
<tr>
<td>Randomization</td>
<td>28</td>
</tr>
<tr>
<td>Aerobic Exercise Training</td>
<td>29</td>
</tr>
<tr>
<td>Resistance Exercise Training</td>
<td>29</td>
</tr>
<tr>
<td>Combination of Aerobic and Resistance Exercise Training</td>
<td>30</td>
</tr>
<tr>
<td>Waitlist Control</td>
<td>31</td>
</tr>
<tr>
<td>Measures</td>
<td>32</td>
</tr>
<tr>
<td>Pedometers</td>
<td>32</td>
</tr>
<tr>
<td>Diet Counseling</td>
<td>32</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>32</td>
</tr>
<tr>
<td><strong>CHAPTER 4: RESULTS</strong></td>
<td>37</td>
</tr>
<tr>
<td>Changes in HRQoL Scores</td>
<td>38</td>
</tr>
<tr>
<td>Fitness</td>
<td>43</td>
</tr>
<tr>
<td><strong>CHAPTER 5: SUMMARY AND CONCLUSIONS</strong></td>
<td>48</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>55</td>
</tr>
<tr>
<td><strong>APPENDIX A: IRB APPROVAL</strong></td>
<td>61</td>
</tr>
<tr>
<td><strong>APPENDIX B: IRB MODIFICATION APPROVAL</strong></td>
<td>62</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1. SF-36 Dimensions .................................................................................................................. 7
Figure 2. Study Flow - From Orientation to Data Analysis ................................................................... 36
Figure 3. Change in PCS, MCS, and Overall Scores within Each Group. .............................................. 41
Figure 4. Average Daily Steps per Week ............................................................................................... 43
Figure 5. Change in Energy Intake between Week 1 and 8 ................................................................. 43
LIST OF TABLES

Table 1. Aerobic Exercise Training Prescription

Table 2. Resistance Exercise Training Prescription

Table 3. Combination of Aerobic and Resistance Exercise Training Prescription

Table 4. Baseline Characteristics

Table 5. Baseline, Follow-up, and Change in Health-Related Quality of Life (SF-36)

Table 6. Average Outside Physical Activity and Diet for the Intervention

Table 7. Baseline and Follow-up Fitness Values

Table 8. Regression: Association of Changes in Fitness (CRF/Muscular Strength) and Changes in SF-36 Scores

Table 9. Attendance and Adherence to Exercise Training
NOMENCLATURE

HRQoL: Health-Related Quality of Life
BMI: Body Mass Index
AET: Aerobic Exercise Training
RET: Resistance Exercise Training
CET: Combination of Aerobic and Resistance Exercise Training
CON: Waitlist-Control
CRF: Cardiorespiratory Fitness
SF-36: Medical Outcomes Study 36-Item Short Form Health Survey
PCS: Physical Component Summary Score
MCS: Mental Component Summary Score
RR: Relative Risk
CI: 95% Confidence Interval
RCT: Randomized Controlled Trial
MET: Metabolic Equivalents
ACSM: American College of Sports Medicine
SLE: Systemic Lupus Erythematosus
PAG: Physical Activity Guidelines
HBM: Health Belief Model
OR: Odds Ratio
6MWT: 6 Minute Walk Test
PAR-Q: Physical Activity Readiness Questionnaire
BMI: Body Mass Index
BIA: Bioelectrical Impedance Analysis
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ABSTRACT

Health-Related Quality Life (HRQoL) is a multidimensional way of examining health which can determine the impact of diseases, injuries, and disabilities on health. The existing literature has mixed findings on which type or combination of exercise most improves HRQoL and is focused on clinical populations with specific conditions. There is a lack of literature on the general population under 65 years old and with lack of time being the most common reason for adults not exercising, an intervention that has similar time requirements for each type of exercise needs to be performed. **Purpose:** The purpose of this study was to compare the effects of aerobic exercise training (AET), resistance exercise training (RET), and a combination of aerobic and resistance exercise training (CET), on HRQoL measured by the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36), specifically in 1) HRQoL in addition to 2) Physical and 3) Mental Component Summary Scores from baseline to the end of the eight-week intervention. **Methods:** Inactive men and women (ages 58 ± 7 years) who were overweight or obese, with elevated blood pressure were randomized to one of three 8-week exercise programs (AET, RET, CET), or a waitlist-control group. All exercise participants had the same exercise duration (time-matched) of three days per week for 60 minutes per session for a total of 180 minutes per week. **Results:** Of the 69 randomized participants, 66 completed the eight-week intervention, however, all 69 were used in an intention-to-treat analysis. Compared to the CON group, the only significant improvements (mean [95% CI] from baseline to follow-up were in the AET group in the subscales of vitality (10.3 [0.7, 19.9]) and social functioning (10.3 [0.7, 19.9])). Based on the baseline and follow-up HRQoL scores, the intervention significantly improved within the AET group in the mental component summary score (4.0 [0.8, 7.3]) and the RET had no significant
improvements. HRQoL. The CET group significantly improved within the overall score (6.4 [1.4, 11.4]), the physical component summary score (3.4 [0.1, 6.8]), and the mental component summary score (3.6 [0.4, 6.7]). **Conclusion:** This preliminary data suggests that performing a combination of aerobic and resistance exercise for one hour, three times per week significantly improves HRQoL, however, large studies with a longer intervention are warranted.
CHAPTER 1: INTRODUCTION

Since 1900, life expectancy has increased about 32 years (National Center for Health Statistics. Health, United States, 2015: With Special Feature on Racial and Ethnic Health Disparities, 2016). Given that people are now living longer, the goal is to have these extra years be quality years which is why Health-Related Quality of Life (HRQoL) is important. HRQoL is based on the way the state of a person’s health impacts both their function and life and therefore influences their quality of life, specifically, their health-related quality of life. Physical, mental, emotional and social functioning are the multidimensional ways of examining health in HRQoL. Healthy People 2020 is a government initiative to improve American’s health by setting ten-year national objectives (“About Healthy People | Healthy People 2020,” 2017). Improving HRQoL aligns with the goal of Healthy People 2020 which is to, “improve health-related quality of life and well-being for all individuals” (“About Healthy People | Healthy People 2020,” 2017).

Studies have found that adults who are physically inactive or have lower fitness tend to report lower scores for HRQoL (Clennin et al., 2015; Pucci, Rech, Fermino, & Reis, 2012; F. Wanderley et al., 2011). Physical activity interventions could improve HRQoL and meet the Healthy People 2020 goal. Studies have shown that people who have higher levels of fitness or who are more active, score higher in certain dimensions of HRQoL such as, physical functioning, vitality, general health, bodily pain, mental health, role limitations due to physical problems, etc. (Abrahão et al., 2016; Myers et al., 2013a; Sillanpää, Häkkinen, Holviala, & Häkkinen, 2012; F. Wanderley et al., 2011). There is evidence that doing a combination of aerobic and resistance training has greater benefits than resistance or aerobic training alone for cardiovascular risk factors in overweight and obese adults (Ho, Dhaliwal, Hills, & Pal, 2012).
Physical activity has many health benefits, but there is mixed research on the effects of physical activity on HRQoL, especially which dimensions are affected by physical activity interventions. The current physical activity recommendations have both aerobic and resistance exercise included. However, there is limited evidence regarding what type(s) of exercise are most effective for improving HRQoL.

The objective of this study is to investigate the independent effects of aerobic and resistance exercise training on HRQoL by analyzing existing data from an eight-week randomized controlled trial of exercise in 69 adults aged 45-74 years old. The study participants were overweight or obese (body mass index [BMI] of 25-40 kg/m²), self-reported that they were inactive meaning they did not meet the aerobic and resistance exercise guidelines over the last three months and had elevated or high blood pressure (systolic/diastolic blood pressure of 120-159/80-99 mm HG without taking antihypertensive medication). Participants with these characteristics should gain health benefits from exercise.

Participants were randomized to one of four groups for their intervention; aerobic exercise training (AET), resistance exercise training (RET), a combination of aerobic and resistance exercise training (CET), or a waitlist-control group (CON). All exercise participants had the same exercise duration (time-matched), of three days per week for 60 minutes per session for a total of 180 minutes per week. HRQoL was measured using the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36). Based on the evidence that CET has health benefits for cardiovascular risk factors in overweight and obese adults, the central hypothesis is that participants in the CET group will have more significant improvements in HRQoL compared to the AET, RET, and CON groups post-intervention. HRQoL was assessed at baseline and at the end of the eight-week intervention.
Specific Aims:

Aim #1: To determine which time-matched exercise intervention shows the greatest improvements in 1) HRQoL in addition to 2) Physical and 3) Mental Component Summary scores from the baseline scores to the end of the eight-week intervention.

Hypothesis:

H<sub>0</sub> Compared to the CON group, the AET, RET, and CET groups will not have significant improvements in HRQoL.

H<sub>a</sub> Compared to the CON group, the AET, RET, and CET groups will have significant improvements in HRQoL.

Aim #2: To determine if changes in physical fitness (cardiorespiratory fitness [CRF] and/or muscular strength) from the baseline assessment to the end of the eight-week intervention are associated with changes in HRQoL.

Hypothesis:

H<sub>0</sub> Changes in CRF and/or muscular strength will not be positively associated with changes of HRQoL.

H<sub>a</sub> Changes in CRF and/or muscular strength will be positively associated with changes of HRQoL.

Health is not just assessing for the presence or absence of disease. The World Health Organization defines health as “a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity” (“WHO | Constitution of WHO,” n.d.). Health is multidimensional and needs to be considered as such and that is why quality of life is so
important. This study will provide preliminary data to determine which type(s) of exercise are most beneficial and whether changes in physical fitness are associated with HRQoL in a high-risk population. Results from this study will contribute to the development of more comprehensive physical activity guidelines and effective public health strategies specific to improving HRQoL.
CHAPTER 2: REVIEW OF LITERATURE

As of 2014, life expectancy in the United States is 78.8 years old, whereas in the 1950’s, life expectancy was 68.2 years old \((National Center for Health Statistics. Health, United States, 2015: With Special Feature on Racial and Ethnic Health Disparities, 2016)\). With life expectancy increasing, it is important to make sure those extra years of life are quality years rather than extra years with an illness, disease or disability especially since the baby boomer generation has reached and continues to reach these extra years of life.

The need to improve quality of life into old age is a growing concern as Healthy People has realized. Healthy People sets goals to improve America’s health by promoting health and preventing diseases. The current goals were made in 2010 and hope to be achieved by the year 2020. Two of the four overarching goals of this initiative are the following 1) “Attain high-quality, longer lives free of preventable disease, disability, injury, and premature death” 2) “Promote quality of life, healthy development, and healthy behaviors across all life stages” \( (“About Healthy People | Healthy People 2020,” 2017)\). Quality of life is one of the main themes of Healthy People 2020, but the definitions of this differs among sources.

Health-Related Quality of Life

In the 2018 Physical Activity Guidelines Advisory Committee Scientific Report, overall quality of life “is a reflection of the way that individuals perceive and react to their health status and to other, nonmedical aspects of their lives”. In short, quality of life refers to overall life satisfaction, which includes health-related and non-health-related quality of life. HRQoL is different because the focus is only on physical and mental health, whereas non-related quality of life contains subscales about finances, occupations and relationships. The most commonly used
measure to determine HRQoL is the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36).

The SF-36 is a self-administered questionnaire and can be measured using a short form of thirty-six questions. The Medical Outcomes Study used a 149-item Functional and Well Being Profile and after multiple versions of a condensed questionnaire, the SF-36 originated (Laucis, Hays, & Bhattacharyya, 2015). There are two versions of the 36-item questionnaire and both are referred to as the SF-36; the Ware-36 and the RAND-36 (Laucis et al., 2015). Both sets of 36 questions examine all dimensions of health and comprise of the following eight scales: physical functioning, role limitations due to physical problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems and mental health. The main differences between the questionnaires is that the RAND-36 questionnaire and scoring is publicly available. The RAND-36 is scored slightly different in the general health and bodily pain subscales. Each item and subscale are scored from zero to one hundred. Even with the slight difference of scoring there is still a high correlation between the two versions of the SF-36 (r=0.99) (Laucis et al., 2015). In both versions, the higher the score means the better the quality of life a person has. The subscales can be summarized into two different categories; a Physical Component Summary score (PCS) and a Mental Component Summary score (MCS). According to Ware & Kosinski, (2001), in the general United States population the two summary scores “capture more than 80% of the reliable variance in the eight subscales…” Advantages of the PCS and MCS scores being calculated include smaller confidence intervals, smaller floor and ceiling effects and less lost statistical power from multiple calculations (Baron, Elashaal, Germon, & Hobart, 2006; Laucis et al., 2015; Ware et al., 1995) The PCS and MCS scores are transformed to permit norm-based
scoring. To do so, some of the subscales are positively weighted while the others are negatively weighted. The positively weighted scales included in the PCS score are physical functioning, role limitations due to physical problems, bodily pain, general health and vitality (Figure 1). In the MCS score, the positively weighted scales are vitality, social functioning, role limitations due to emotional problems and mental health. Scores above 50 show above average health status while a score below 50 is below average health status. The potential scores for the PCS score are 20-58 with a standard deviation of 3 and for the MCS score, the scores are expected to be between 17 to 62 also with a standard deviation of 3 (Reid et al., 2010).

According to (Lins & Carvalho, 2016), a total overall score cannot be calculated for the SF-36, although it is frequently cited in the scientific literature. From their systematic review, most studies did not report how they calculated the overall score, but the most common way specified was using an average score of the eight subscales. The SF-36 summary scores and subscales can be used to determine impact of diseases, injuries and disabilities (Yin, Njai, Barker, Siegel, & Liao, 2016). With this capability, the impact of exercise on diseases, injuries and disabilities can also be examined.

**Figure 1. SF-36 Dimensions**

- **PCS**
  - Physical functioning
  - Role limitations due to physical problems
  - Bodily pain
  - General health
- **MCS**
  - Social functioning
  - Role limitations due to emotional problems
  - Mental health
- **Overall**
As a Predictive Measure

The impact of conditions on HRQoL can be examined and HRQoL also has the capability of being a predictive measure of health. This is due to the fact that the SF-36 is comprised of eight subscales that summarize the different areas of health. Researchers have realized this capability and found associations between HRQoL and first emergency room hospitalization, mortality and physical activity. The predictive nature of HRQoL may help identify cues when medical care needs to be sought or a lifestyle intervention needs to take place.

Researchers have studied HRQoL to see if it is predictive of first emergency room rehospitalization and mortality. In a longitudinal study of 394 patients with heart failure, Rodríguez-Artalejo and colleagues (2005) found an association between HRQoL and first emergency room rehospitalization. Those who scored below the median scores for any of the subscales were more frequently readmitted to a hospital compared to those who scored above the median in all the subscales except for role limitations due to physical problems and bodily pain (p<0.05). After further adjustment for confounding variables, the hazard ratios and 95% confidence intervals (CI) (HR [CI]) were as follows: physical functioning (HR 1.65 [CI 1.11, 2.44]), general health (HR 1.73 [CI 1.19, 2.52]; p=0.003), mental health subscales (HR 1.65 [CI 1.10, 2.47]), and PCS scores (HR 1.52 [CI 1.04, 2.21]), remained significant for rehospitalization. When examining HRQoL and mortality, association were found in the following subscales: physical functioning (HR 2.08 [CI 1.16, 3.72]), general health (HR 1.72 [CI 1.00, 2.96]), vitality (HR 2.08 [CI 1.22, 3.53]), and mental health (HR 2.46 [CI 1.38, 4.40]). Based on these findings, low HRQoL may be a predictor of hospitalization and death among the general population.

Kroenke and colleagues analyzed the Nurses’ Health Study (Kroenke et al., 2008). This study consisted of 40,377 women and examined if recent self-reported HRQoL scores and
changes in HRQoL predict mortality in healthy women. The 46 to 71-year-old nurses completed the SF-36 questionnaire. The researchers scored the questionnaire and categorized the subscales into the PCS and MCS scores. When looking at recent scores of the PCS and MCS scores, Kroenke and colleagues found that those who scored low had a higher subsequent mortality. The findings were analyzed using relative risks (RR) and CI. Those with scores of 0 to 30 in the PCS score had a RR of 2.43 (CI 1.65, 3.58), scores of 31 to 51 had a RR of 1.24 (CI 0.87, 1.77), and scores of 51 to 60 had a RR of 0.87 (CI 0.61, 1.24) when compared to those with better HRQoL (PCS score of 61 to 75). When the MCS scores were examined, those with scores of 0 to 30 had a RR of 1.12 (CI 0.74, 1.67), scores of 31 to 50 had a RR of 1.15 (CI 0.96, 1.37), and scores of 51 to 60 had a RR of 0.97 (CI 0.83, 1.14) compared to those who scored 61 to 75. Poor and declining scores in HRQoL as predictive measures of mortality are consistent with previous studies who examined specific populations of people (e.g., older adults, adults after coronary artery bypass graft surgery, veterans with arthritis, asthma, COPD, etc. (Dominick, Ahern, Gold, & Heller, 2002; Dorr et al., 2006; Fan, Au, McDonell, & Fihn, 2004; Knight, Ofsthun, Teng, Lazarus, & Curhan, 2003; S. J. Lee, Lindquist, Segal, & Covinsky, 2006; Mapes et al., 2003; Rumsfeld et al., 1999; Singh, Nelson, Fink, & Nichol, 2005; Sprenkle, Niewoehner, Nelson, & Nichol, 2004).

In the same study, Kroenke and colleagues also examined the changes of HRQoL scores based on two four-year time periods. Baselines scores were measured between 1992 and 1996 and follow up scores were taken between 1996 and 2000. They found that those who had low HRQoL had a higher relative risk of mortality. The following results from this study were compared to those who had continued good health, so they maintained a score above 50 for the PCS and MCS score during both four-year time periods. Those who had recovering health for
PCS (low baseline scores of less than 50 and improved score to greater than 50) had a RR of 1.12 (CI 0.85, 1.47). If participants had declining health for the PCS (baseline scores of greater than 50 and decreased to less than 50), they had a RR of 1.58 (CI 1.30, 1.91). Lastly, those who had continued poor health for the PCS scores (continued low score of less than 50) had a RR of 1.77 (CI 1.49, 2.10). When examining the MCS scores, women with recovering health had a RR of 1.13 (CI 0.091, 1.39), declining health had a RR of 1.43 (1.15, 1.78), and continued poor health had a RR of 1.28 (CI 1.03, 1.59). The nurses who had decreased PCS scores were more predictive of mortality compared to decreased scores in the MCS. With evidence that lower scores of the SF-36 and decreasing scores over time, particularly in the PCS scores being associated with mortality, a solution such as physical activity may be especially useful.

Pucci, Rech, Fermino, & Reis (2012) performed a systematic review looking at the association between physical activity and quality of life in adults and found that a higher level of physical activity was associated with a better perception of HRQoL in elderly, healthy adults and individuals with different diagnosed conditions. Over two-thirds of the studies included in this systematic review were cross-sectional studies, while 18% were experimental, 8% were prospective cohort and 5% had a mixed design which was cross-sectional and longitudinal. The majority (82%) of the studies used self-reported physical activity and the consensus among the studies was that there is a positive association between physical activity and the following HRQoL subscales: physical functioning, role limitations due to physical problems, general health, vitality, role limitations due to emotional problems, mental health, the PCS scores and the MCS scores. The only subscales that did not have agreement for an association between the studies were social functioning and bodily pain. These studies looked at doses of physical activity and found it is not just beneficial for HRQoL scores, it also decreased their risk of
chronic health conditions. Another systematic review by Bize, Johnson, & Plotnikoff (2007) found that when reviewing cross-sectional studies (n=7), cohort studies (n=2), and a mixed design study, there was a positive association between self-reported physical activity and HRQoL. The cross-sectional studies used self-report questionnaires about physical activity. A limitation of self-report questionnaires about physical activity is that people over-report their activity (Dyrstad, Hansen, Holme, & Anderssen, 2014).

According to the 2014 National Health Interview Survey and the analysis by the Centers of Disease Control and Prevention (CDC) on the 2011 Behavioral Risk Factor Surveillance System self-report questionnaires of physical activity, approximately 20% met the physical activity guidelines (Blackwell, Lucas, & Clarke, 2014; Centers for Disease Control and Prevention (CDC), 2013). However, (Troiano et al., 2008) found that only 5% of adults actually met the physical activity guidelines when physical activity was objectively measured by an accelerometer. To better recommend what adults need to do for physical activity to benefit their HRQoL, objective measures of physical activity in longitudinal studies or randomized controlled trials should be done.

The major limitation of cross-sectional studies is that they only examine variables of interest during one point in time. Due to this, it cannot be determined if the exposure happened before the outcome (i.e. person became physically active and HRQoL scores increased) or the outcome occurred before the exposure (HRQoL scores increased and then person became physically active). Cross-sectional studies are useful to measure multiple exposures and outcomes at one time. With this, a hypothesis can be made from these studies and then tested with the gold standard of studies; a randomized controlled trial (RCT). A RCT randomizes individuals into a treatment or a control group so there is a standard for comparison. The
randomization eliminates selection bias and causal inferences can be made which is why a RCT would be useful to determine the effects that physical activity has on HRQoL.

**HRQoL in Randomized Controlled Trials**

When reviewing the current literature, different dimensions of HRQoL were impacted differently across various RCTs. The studies randomized the participants to a CON group, AET group, RET group and/or a CET group. The differing results of the RCTs are aligned with the American College of Sports Medicine (ACSM) position stand for the benefit of physical activity on quality of life. The 2009 position stand stated, “Although physical activity seems to be positively associated with some aspects of QOL, the precise nature of the relationship is poorly understood” (Chodzko-Zajko et al., 2009). The following review of six RCTs will show mixed findings that physical activity interventions had on HRQoL scores. These RCTs were closely related to the study analyzed and had to include adults, compare AET, RET, CET and/or CON, and use the SF-36 to measure HRQoL.

Sillanpää et al. (2012) analyzed 204 healthy, untrained, 40 to 80-year-old adults who participated in 21 weeks of AET, RET, CET and a CON group. The AET and RET groups trained two days per week while the CET group did both AET and RET, which resulted in four days per week of exercise. The SF-36 was translated to Finnish and used for this study. Following the intervention, the AET group had significant improvements (p<0.05) in the dimensions of general health (Δ 4.35 ± 2.02), bodily pain (Δ5.47 ± 2.45) and role limitations due to physical problems (Δ5.98 ± 2.36). The RET group had a significant increase in bodily pain, meaning it got worse (Δ-5.35 ± 1.84, p<.05), and the CET group had significant improvements in general health (Δ4.61 ± 1.92, p=0.020), mental health (Δ3.86 ± 1.43, p=0.009) and vitality (Δ6.57 ± 1.54, p<0.001). Between the groups, there was a significant difference of the training
interventions in vitality. This study benefits of exercise for HRQoL in healthy, untrained adults, but there may be different effects of exercise programs and in different populations.

Reid et al. (2010) examined 218 inactive, 39-70-year-old adults with type 2 diabetes mellitus and assessed the effects of AET, RET, CET and a waitlist CON on HRQoL. The participants exercised three times per week, for six months and progressed in duration and intensity. The AET group did 20-45 minutes and the RET group did two to three sets and progressed when more than eight repetitions could be lifted. The CET group did the full programs of the AET and RET. For the CET group doing twice the amount of exercise as the other two groups, there were not significant changes in either of the component summary scores from baseline to the end of the intervention for the SF-36. The RET group improved their scores for the PCS score more when compared to the AET group (Δ2.7, p=.048) and the CON group (Δ3.3, p=.015), but when confounding variables were controlled for (age, sex, baseline HbA1c and BMI), these results were no longer significant. Surprisingly in this study, the CON group improved their MCS score compared to the RE (Δ-7.6, p<.0001) and CE (Δ-7.2, p<.0001). The CON group may have significantly improved the MCS score because the CON group’s scores were significantly lower at baseline compared to the other groups. To see if the MCS scores improved with an intervention for the CON group, a similar study by Myers et al., was examined.

Like Reid et al. (2010), Myers et al. (2013b) analyzed 262 adults, aged 30-75 years old, who were sedentary and had type 2 diabetes. Participants were randomized to four groups for the 9-month intervention: AET, RET, CET and CON. The exercise prescription for the AET group was equivalent to performing 150 minutes of moderate intensity activity (~10-12 kcal/kg/week). The RET group trained three days per week and CET group did two sessions of strength training
per week and the aerobic activity was equivalent to 150 minutes moderate intensity activity. These exercise prescriptions made the groups have similar time requirements, unlike Reid et al. (2010), where the CET group was doing the full programs of the AET and RET. Significant improvements were found when comparing HRQoL results to the control group (RET p=0.005, AET p=0.001, and CET p=0.015). Performing aerobic exercise improved the PCS score, and the subscales of physical functioning and general health. Participating in strength training improved the PCS scores and the subscales of bodily pain and general health. Lastly, performing both aerobic and resistance exercise, improved the PCS score, and the subscales of physical functioning, general health and vitality. All groups had significant improvements in the PCS score. When comparing the AET and the RET to the CET group, the CET group improved all subscales that the AET group did, but the CET group did not improve bodily pain like the RET group did. The CET group did show significant improvement in the vitality subscale, whereas AET and RET did not. Reid et al. and Myers et al. had similar populations, but only Myers and colleagues found significant improvements in some of the subscales of the SF-36. The difference of the results could be attributed to the fact that each exercise group was matched for time or the difference in the exercise prescriptions.

Nicolucci et al. (2012) analyzed the effects of exercise volume in sedentary adults with type 2 diabetes mellitus. The 606 participants were randomized to one of two groups; CET or CON. The CET group trained for 150 minutes per week on two days and the CON group received counselling for their standard care. The aerobic portion of the CET was based off a percentage of maximal oxygen consumption and the resistance exercise was prescribed based on 1-repetition maximum changes throughout the study. Energy expenditure was progressively increased by 0.4184 kJ/kg body weight per session every month. Metabolic equivalent (MET)
was recorded by the aerobic machines and for the resistance exercise, a conservative value of 3 MET-hours was used to find exercise volume (Balducci et al., 2010). Although not significant for all the exercise volumes when organized into quintiles, a positive trend was found when comparing the CON and the CET exercise volume. As the exercise volume increased, the SF-36 subscale scores did as well. When looking at the PCS score, there was improvement when the exercise volume was above 17.5 MET-hours/week and for the MCS score, there was improvement no matter what the volume of exercise was. Time and intensity of exercise may be the determining factors of improvement in SF-36 scores in adults who are relatively healthy or have a condition.

Abrahão et al. (2016) randomized 63 patients over the age of 18 with systemic lupus erythematosus (SLE) into either AET, RET or a CON group for a twelve-week intervention. This population was examined because exercise has been shown to be beneficial for people with SLE just like it has been shown for those with elevated blood pressure (Abrahão et al., 2016). The exercise sessions were 50 minutes, three times per week. The AET was at 65%-75% of the participant’s heart rate reserve and the RET group performed eight exercises using elastic bands or free weights and did three sets of 15 repetitions (65-75% of their one-repetition maximum). The SF-36 was used to measure HRQoL before and after the intervention. From the 12-week intervention, all subscales of the SF-36 were improved for both the AET and the RET groups except the vitality subscale for the RET group. When comparing the AET group to the RET group and the CON group, the subscales of vitality and role limitations due to physical problems were significantly different (p<0.05), with the AET group scores being higher at the end of the intervention. This was not the case for the RET group, however, when it was compared to the
CON group. The study suggests that AET may shower greater improvements in SF-36 scores compared to RET, which differs from the findings of the previous studies.

Wanderley et al. (2015) conducted an eight-month study with 75 older adults randomized into three groups: AET, RET and a waitlist CON group. The exercise sessions were three days per week for approximately fifty minutes. AET was based on 50% to 80% heart rate reserve with the participants maximum heart rate being estimated from (Tanaka, Monahan, & Seals, (2001) equation. For RET, baseline one-repetition maximum (1-RM) was found for all twelve resistance machines. Prescriptions of weights were between 40% and 80% of 1-RM and two sets of eight to fifteen repetitions were completed. The researchers found that the AET group had improved more than the CON group in the general health and mental health subscales (p≤.01). From the intervention, the PCS score was significantly improved compared to the CON group in both the exercise groups when considering the group by time interaction (p≤.04).

Between the research studies, one of the most commonly affected scores of the SF-36 was the PCS score, which is an aggregate, weighted score of the subscales (Myers et al., 2013b; Nicolucci et al., 2012; F. A. C. Wanderley et al., 2015). When comparing the exercise groups to the CON group, the exercise participants had improvements when the weekly exercise volume was above 17.5 MET hours/week. This amount of physical activity is equivalent to 1,050 minutes per week which is just above the physical activity recommendations of a total of 500 to 1,000 MET/minutes performed in a week (Ferguson, 2014). Considering that the percentage of adults who self-report that they meet the physical activity guidelines is approximately 20%, the recommendation of doing slightly above the physical activity guidelines may not be attainable (Blackwell et al., 2014; Centers for Disease Control and Prevention (CDC), 2013). The CET did not necessarily improve all the subscales that AET and RET did. This could be because the CET
The most beneficial mode of exercise to improve HRQoL is not apparent. Two reasons why the results of these exercise interventions did not show the same subscale improvements for HRQoL may have been because of the differences in the participant population and the exercise prescriptions. A limitation with using inactive adult populations with diseases is that the improvements that they had for HRQoL may not happen in a general inactive adult population, which is prone to having hypertension. Hypertension is defined as having too high of blood pressure within the blood vessels. Based on the American Heart Association and American College of Cardiology redefining blood pressure guidelines, now 46% of United States adults have hypertension, whereas before only 32% of these adults had hypertension prior to redefining the guidelines (American Heart Association News, 2018). Hypertension is considered a silent killer because the only way a person knows they have it is by getting their blood pressure checked frequently (“Why High Blood Pressure is a ‘Silent Killer,’” 2018). The general population may experience different effects from physical activity because of the way the disease affects their everyday life. The differences within the exercise prescriptions may also be the reason as to why sometimes the AET, RET and CET groups improved HRQoL and sometimes
they did not. The most beneficial mode of exercise may not be clear, but a commonality between the studies is that physical activity was beneficial for improving the PCS score (Myers et al., 2013b; Nicolucci et al., 2012; Reid et al., 2010; F. A. C. Wanderley et al., 2015). Because the PCS score is an aggregate, weighted score of the eight subscales of the SF-36 and it was the most common improvement in the six studies, inactive adults, no matter the population, should do some form of exercise to improve HRQoL since these studies found different prescriptions of AET, RET, and CET improve HRQoL scores.

**Physical Activity Guidelines**

According to the American College of Sports Medicine, the current physical activity guidelines state that adults should get at least 150 minutes a week of moderate intensity physical activity, 75 minutes of vigorous intensity physical activity, or an equivalent combination of moderate and vigorous intensity physical activity. If a person does 300 minutes of physical activity, there are additional health benefits. The guidelines also state that on two or more days per week, adults should perform muscle-strengthening activities which targets all of the major muscle groups (Ferguson, 2014). Physical activity recommendations have been established for adults, but people still do not follow them even though there are many health benefits. The 2008 Physical Activity Guidelines for Americans (PAG) has recognized that in the United States, physical activity must be done during leisure time because of the lack of opportunity for work or transportation-related physical activity.

**Barriers to Exercise**

Justine and colleagues (2013) used the Health Belief Model (HBM) to identify barriers to participation in exercise. The top three external reasons for not exercising for 60 middle-aged adults were because “not enough time” (46.7%), “no one to exercise with” (40.0%) and “lack of
facilities” (33.4%). The most common internal reasons for not exercising were because “too
tired” (48.3%), “already active enough” (38.3%), “do not know how to do it” (36.7%) and “too
lazy” (36.7%) (Justine et al., 2013). Being too tired and not having enough time may be because
of all the commitments adults have in life. With limited time, the mode of exercise that most
improves HRQoL should be the focus. The 2018 Physical Activity Guidelines Advisory
Committee Scientific report has identified that further research needs to be done on the effects of
strength training on quality of life within a randomized controlled trial because the effects of
aerobic exercise have been studied extensively. However, the mixed results that exercise has on
quality of life may be due to physiological adaptations (e.g. changes in CRF and muscular
strength) between aerobic exercise and resistance exercise.

**Importance of Fitness**

CRF is a “health-related component of physical fitness that relates to the ability of the
circulatory and respiratory systems to supply fuel during sustained physical activity and to
eliminate products after supplying fuel” (Caspersen, Powell, & Christenson, 1985).

Nonmodifiable factors that influence CRF include, age, gender and genotype. The modifiable
factors that contribute to CRF are physical activity, smoking, obesity and medical conditions. To
see if CRF changes over time, a maximal or submaximal CRF test can be completed. CRF can be
most improved by performing aerobic exercise because it increases stroke volume and decreases
venous oxygen content, which results in an increase in oxygen extraction by the muscles (Ross et
al., 2016). Being physically active is the biggest contributor to CRF and muscular strength, so a
greater emphasis needs to be put on meeting the physical activity guidelines. This includes doing
at least two days of resistance exercise training per week.
After the age of 30, muscle mass declines between three to eight percent each decade of life (Evans, 1997; Flack et al., 2010; Forbes & Reina, 1970; Kallman, Plato, & Tobin, 1990). Not maintaining muscle mass and muscular strength can contribute to decline in functional capacity, increased risk of fall and fractures and an increased risk of developing chronic metabolic diseases (Evans, 1997; Forbes & Reina, 1970). The rapid decline of muscle mass after the age of 30 and the risks of losing muscular mass and strength, has led researchers to examine the effects of muscular fitness on HRQoL.

Wanderley and colleagues (2011) found that as physical fitness increased, some subscales of the SF-36 did as well. The researchers used odds ratios (OR) and CI to examine the relationship between an increase in fitness with scores in the HRQoL subscales. For each increase of hand-grip strength (muscular strength) measured in kilograms, the odds of scoring in the highest quartile of the SF-36 subscale scores were as follows: role limitations due to physical problems (OR 2.37 (CI 1.33–4.24); p<0.01), vitality (OR 1.83 (CI 1.13–2.98); p=0.01), and mental health (OR1.30 (CI 0.78–2.17); p=0.32). However, mental health was no longer significant after adjusting for confounding variables. This study also examined CRF using the six-minute walk test (6MWT). Improving the participant’s 6MWT time made them more likely to improve in physical functioning (OR 1.87 (CI 1.03–3.38); p=0.04), role limitations due to physical problems (OR 1.95 (CI 1.12–3.39); p=0.02), and vitality (OR 1.79 (CI 1.08–2.97); p=0.03) even after controlling for confounding variables. Because improving both CRF and muscular fitness improved subscales of HRQoL, this study suggests that being fitter may improve SF-36 scores more compared to someone that has low fitness. Being active is the biggest contributing factor to CRF level, so having better fitness may be attributed to a person being more active (D. Lee, Artero, Sui, & Blair, 2010).
The RCT mentioned earlier by Sillanpää and colleagues (2012) examined the changes of CRF and muscular strength from pre- to post-intervention for all the randomized groups. For testing CRF, they used a graded exercise test on a cycle ergometer. From the participants baseline to their post-intervention, the AET group’s $V_{O_2}max$ changed by 16.13±13.75%, $p<0.001$, RET group did not have a significant change (4.07±14.58%, $p=0.137$), the CET group changed by 12.41±10.42%, $p<0.001$, and the CON group also did not have a significant change in $V_{O_2}max$ (1.57±9.59%, $p=0.471$). The association between CRF and the HRQoL were next examined. At baseline for all the groups, there was a significant association with the following subscales: physical functioning: $r=0.27$, $p<0.001$, general health: $r=0.15$, $p=0.049$, and vitality: $r=0.24$, $p=0.002$. During the intervention and within the AET group, an association was found in the change of bodily pain subscale: $r=0.40$, $p=0.016$ and a change in $V_{O_2}max$. For the CET group, there was an association with the change in general health: $r=0.40$, $p=0.004$ and the change in $V_{O_2}max$. Training two to four times per week for 21 weeks showed significant changes in CRF for Sillanpää and colleagues, but not for Reid et al. (2010). Reid and colleagues performed a graded exercise test on a treadmill until exhaustion and found that there were no significant associations between changes in CRF and changes in HRQoL. This also held true when they examined the changes in muscular strength with changes in HRQoL. However, this was not the case for Sillanpää and colleagues. When Sillanpää and colleagues tested muscular strength the CET group produced the greatest changes. Muscular strength was tested using a 1-RM test on the leg press. The AET group changed their muscular strength by 5.01±6.83%, $p<0.001$, the RET group by 15.05±10.17%, $p<0.001$, the CET group by 17.47±9.88%, $p<0.001$ and the CON by 3.27±6.47%, $p=0.001$. At baseline, an association between muscular strength and HRQoL was found in the vitality subscale: $r=0.22$, $p=0.004$ when examining all participants.
There were no other significant associations with muscular strength and scores in the HRQoL subscales for the groups individually. Based on these two studies, changes in CRF may be a bigger influence on changes in HRQoL. This may be because of all the systems in the body that have to work together to improve CRF.

**Conclusion**

The existing literature on the impact of aerobic exercise, resistance exercise, a combination of aerobic and resistance exercise on HRQoL is focused on clinical populations with specific conditions. These include but are not limited to people with type 2 diabetes mellitus, systemic lupus erythematosus, older adults, etc. There is a lack of literature that examines more of the general population under 65 years old (Bize et al., 2007). Middle-aged adults should be studied in exercise interventions and the goal should be to prevent the decline of HRQoL before other health conditions may arise. Only about 5% of the adult population are meeting the physical activity guidelines and low levels of physical activity are associated with many chronic diseases such as: diabetes, stroke, coronary heart disease and obesity. Being physically active can help with weight maintenance, lower blood pressure, reduce the risk of falls, prevent and/or improve mild to moderate depression, lower the risk of cognitive decline and dementia, etc. (Garber et al., 2011). According to a CDC report by Watson and colleagues (2016), physical inactivity prevalence increases with age. Among 50 to 64-year old adults, about 25.4% of them were inactive and the prevalence increased about 10% among those who were 75 years old or older. An exercise intervention that teaches people to build exercise into their day, that provides social support, access to a facility and teaches people how to exercise correctly will help combat the increased prevalence of physical inactivity.
By analyzing the data from the time-matched intervention, the type(s) of exercise that most affect HRQoL will be determined. To give clarity on which type of exercise is most beneficial for all aspects of health, an intervention that has similar time requirements for each group needs to be performed. A unique aspect of this study was that Technogym was used to prescribe and track exercise regimens. The exercise program was three days per week for an hour and all the participants met the physical activity guidelines. The exercise regimens were personalized based on the participant’s assessment results and gradually progressed in duration, intensity, sets and weight, so it was equivalent of having a personal trainer. Using Technogym allowed for examination of prescribed and performed sets, weight lifted, duration, average heart rate and much more. With this, more conclusive data on what the exercise regimen entails for AET, RET or CET can be correlated with physical fitness and HRQoL. Physical fitness (CRF and muscular strength) was measured at baseline and at the end of the eight-week intervention.
CHAPTER 3: METHODOLOGY

Participants

Men and women between 45 and 74 years old were recruited for this study. To be eligible, the following criteria had to be met; non-smoker, body mass index of 25-40 kg/m², meeting neither aerobic nor resistance activity guidelines and a systolic/diastolic blood pressure within the range of 120-159/ 80-99 mm Hg without taking blood pressure medication. Participants who have these characteristics are expected to gain cardiovascular benefits by doing physical activity, thus we may see changes in HRQoL, since different dimensions of health are examined in the SF-36 (Donnelly et al., 2009; Pescatello et al., 2004).

Participants were excluded if they had medical problems that interfered with exercising. Such problems included: unstable coronary heart disease or decompensated heart failure, severe pulmonary hypertension, aortic stenosis, acute myocarditis, endocarditis, pericarditis, aortic dissection, pregnant women and those who are planning to be pregnant during the intervention and/or those who plan to be away for more than two-weeks during the 8-week intervention period. This study was approved by the Institutional Review Board (IRB) at Iowa State University. The approval forms are available in the Appendices.

Procedures

Phone Screening

This study compared the effects of aerobic exercise training only (AET), resistance exercise training only (RET) and a combination of both aerobic and resistance exercise training (CET) on the effects on blood pressure and other cardiovascular risk factors. These effects were also compared to a control group who did not exercise (CON). Participants who were interested
in the study went through a phone screening to see if they met the initial inclusion criteria. The participants were asked about their age, smoking status, height, weight, blood pressure medication, physical activity, pregnancy, history of a heart attack, stroke, cancer or diabetes. If the potential candidates met the initial phone screening criteria, they were then invited to an orientation session. The full study flow from orientation to data analysis can be found below in Figure 2.

**Orientation and Education Sessions**

At the orientation session, the potential participants learned more about the expectations and flow of the study. They signed an informed consent, completed the Medical History Questionnaire, which includes family and personal health history and completed the (PAR-Q). Peripheral blood pressure was measured to see if they met the inclusion criteria of (120-159/80-99 mm HG). Height and weight were measured in a private room to determine their BMI. Participants were overweight or obese class 1 or 2 (BMI of 25-29.99 kg/m², 30-34.99 kg/m², and 35-39.99 kg/m², respectively), as defined by the National Heart, Lung, and Blood Institute (*Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*, 2000). After the orientation sessions, the next steps included two different days of education sessions.

Education session one focused on the benefits of exercise and cardiovascular disease. Education session two focused on the capabilities of Technogym for the exercise intervention, an introduction to the maximum muscular strength tests and the CRF test that occurred during the second assessment day at baseline and again after the eight-week intervention. After completing the orientation and education sessions, the participants then started the baseline assessments.
Assessments

Day 1
The participants completed two days of baseline assessments. These two days of assessments were repeated at the end of the eight-week intervention. All the measurements were completed in the same laboratory and standardized for the time of day they occurred. On the first day of the assessments, participants filled out the Medical Outcomes Study 36-Item Short Form Survey, which measures HRQoL and had their height and weight measured.

A standard stadiometer was used to measure the participant’s height (cm) and weight (kg). Participants wore light clothes and shoes were removed prior to the measurement. From these measurements, BMI (weight in kilograms divided by height in meters squared [kg/m\(^2\)]) was calculated. Body composition was measured via two different methods; a bioelectrical impedance analysis (BIA) and skinfold measurements. BIA was measured using the InBody 720 (Biospace Co, Ltd, Seoul, Korea). Participants did not wear shoes and stepped onto the device to have their weight (kg), BMI (kg/m\(^2\)), body fat percentage (%), fat mass (kg) and fat free mass (kg) calculated.

Day 2
On the second assessment day, the participants completed a submaximal CRF test and a strength test for their upper and lower body. The CRF test used the modified Balke and Ware Treadmill Test. This test is specifically designed for older, deconditioned individuals using a treadmill or cycle ergometer, which was appropriate for the current study participants who had increased blood pressure, were overweight or obesity, were inactive adults, and aged 45-74 years old. The participants started walking at a speed of 3.3 miles per hour (mph) at a 0% grade for one minute. Next, the grade increased to 2% for one minute with the speed staying the same. A speed
of 3.3 mph was maintained throughout the whole test and every minute the grade increased by 1%. The participants walked until they reached 70% of their heart rate reserve (equivalent to 85% of the age-predicted maximal heart rate) (Ferguson, 2014). Heart rate and the participants rating of perceived exertion using the Borg’s Scale were monitored at the end of each minute (Borg, 1982). After the test was stopped, the total time of the test was recorded and then the participants completed a cool-down period of at least five minutes. A maximal CRF test was not performed in this study because of the potential risks of maximal CRF test in this high-risk population. However, the correlation between submaximal and maximal CRF tests is strong (r=0.7-0.9) (Noonan & Dean, 2000). The following equation by ACSM was used: 3.5 + (0.1 x speed) + (1.8 x speed x grade) to estimate CRF (Ferguson, 2014).

On the second assessment day, participants completed a strength test to find their absolute 1-RM for the upper body (chest press) and lower body (leg press) using the Technogym Wellness System (Baechle, Earle, & Association (U.S.), 2000). After the participant was properly fitted for the resistance machine, the participant selected a warm-up weight, which was considered a light resistance. The load increased approximately 10 to 20 pounds (or 5%-10% of body weight) for upper body and 30 to 40 pounds (or 10%-20% of body weight) for lower body until the maximum load was reached. Between each set, a rest time of at least two-minutes was taken. While maintaining proper form and lifting through the entire range of motion, the absolute 1-RM was found when the participant could no longer increase the load (Baechle et al., 2000). If a participant maxed out the load capacity of the machines, their 1-RM was estimated using a training load chart (Lander, 1985).

After completing both assessment days, the participants received an incentive of twenty dollars at both the baseline and the post-intervention measurements. Those who completed both
the baseline and follow-up measurements were entered into a drawing where one randomly selected person won $200. This promoted compliance for the intervention. If participants did not perform the follow-up assessment, the participants did not complete the study and were considered a dropout.

The original study also included various cardiovascular health outcomes such as peripheral and central blood pressure, waist circumference, body composition, fasting lipids and glucose. However, the analysis of this study will focus on HRQoL and its components as the primary outcome and CRF and muscular strength as secondary outcomes.

**Randomization**

The participants were randomized into one of the four exercise training groups (AET, RET, CET, CON) by block randomization based on age, sex, baseline blood pressure and body mass index (BMI). The participants who were randomized into one of the three exercise training groups completed supervised exercise, as detailed in Tables 1-3 at the Physical Activity Epidemiology Lab in Forker at Iowa State University. Each exercise group came in three days per week (every other day) for the entire eight-week intervention. Workouts were assigned to the participants using the Technogym Wellness System which is computer-based exercise programing and monitoring software. The workouts were personalized to the participant based on their baseline CRF test and muscular strength tests. The Technogym Wellness System tracked attendance, being the number of days the participants came to exercise (maximum of 24 sessions), and adherence which was defined as the performed exercise divided by the prescribed exercise for each workout over the intervention period. Although the exercise was prescribed, the participants still had control over increasing or decreasing the prescription. If adjusted, the machines recorded what was performed.
Aerobic Exercise Training

The AET group gradually progressed to doing sixty minutes of aerobic exercise at a moderate to vigorous intensity, which was between 40% and 70% of their heart rate reserve (Table 1). Participants could exercise at a higher intensity; however, they could not exceed 80% of their heart rate reserve. Heart rate was tracked using a Polar Heart Rate Monitor to ensure the participants were keeping their heart rate at the desired prescription each exercise session. The aerobic equipment included: a treadmill and cycle ergometer.

Table 1. Aerobic Exercise Training Prescription

<table>
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<th>Week</th>
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Resistance Exercise Training

The RET group gradually progressed from one set of 18 repetitions for their upper body and 20 repetitions for their lower body to three sets of ten repetitions for their upper body and fourteen repetitions for their lower body over the eight weeks (Table 2). The twelve machines targeting each of the major muscle groups used were the chest press, shoulder press, lat pull down, lower back extension, abdominal crunch, torso rotation, biceps curl, triceps extension, leg press, quadriceps extension, leg curl and hip abduction. When the participants could perform all
sets and repetitions at the weight prescribed, they were encouraged to increase their weight until they reached exhaustion on the last repetition indicating the lower the repetition, the higher the intensity. Participants could modify the weight lifted if it was changed from what was prescribed, directly on the weight machines.

**Table 2. Resistance Exercise Training Prescription**

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**Combination of Aerobic and Resistance Exercise Training**

The CET group completed thirty minutes of aerobic exercise and thirty minutes of resistance exercise per session. The participants used the same aerobic protocol, but it was for half the amount of time. To accommodate the thirty-minute time frame for the resistance exercise, the participants performed eight of the twelve exercises and they only progressed to performing two sets instead of three sets (Table 3). The exercises not performed used smaller muscle groups and were the shoulder press, arm curl, arm extension and leg extension.
Table 3. Combination of Aerobic and Resistance Exercise Training Prescription

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<td>8</td>
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<td>30 70 2 10 14</td>
<td>30 70 2 10 14</td>
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</table>


Waitlist Control

The control group was asked to maintain their current physical activity behaviors for the intervention period. After the eight-week intervention period, they received their choice of participating in any of the exercise training groups. They performed the assessments again at sixteen-weeks, so they could compare their results of when they were not exercising (weeks 1-8) versus exercising intervention (weeks 9-16). These results were not used for the analysis and were only for the participant’s knowledge.
Measures

Pedometers

All participants wore an accelerometer-based pedometer (OMRON HJ-321, OMRON Healthcare, Hoofddorp, Netherlands) to track their steps for the entire intervention. The participants were asked to remove their pedometers while they did their assigned exercise intervention. The participants recorded their daily step counts and how long they wore the pedometer and then turned them in once a week. The control group was able to do this through a text message, email or phone.

Diet Counseling

All study groups received the same dietary counseling by a registered dietician based on the Dietary Approaches to Stop Hypertension (DASH) Diet (Sacks et al., 2001) to minimize dietary variability among groups (Sigal, 2007). The focus of this counseling was on changing the quality of the diet without changing the total energy intake to avoid weight loss. During the first and eighth week of the intervention, participants completed a three-day diet record that was analyzed using The Food Processor Diet and Nutrition Analysis Software (ESHA, Salem, Oregon).

Statistical Analysis

The primary outcome variables included each of the eight subscales of HRQoL; physical functioning, role limitations due to physical problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems and mental health, as well as the PCS, MCS and the overall score. Secondary outcomes included, time (baseline/follow-up after the 8-week intervention), CRF and muscular strength.
All participants were included in the intention-to-treat analyses using the last observation carried forward method and all randomly allocated persons at baseline were included. The HRQoL questions were scored using the RAND-36 scoring method, so questions were scored on a scale of 0-100 with equal distances between each response (e.g. items were scored as 0, 25, 50, 75, or 100). Reverse scoring was used for negatively-keyed items. A mean for all questions pertaining to each subscale was found to determine the overall score from the survey. To calculate the summary scales, the subscales were standardized using a linear z-score transformation (equation below). The subscale average of the general population was subtracted from the subscale score and that number was divided by the standard deviation of the general U.S. population. The subscales were then multiplied by the respective coefficients for the subscale based on if the PCS or MCS score was being calculated. Lastly, t-scores were calculated by multiplying the PCS or MCS score calculated in step 2 by 10 and then 50 was added (Taft, Karlsson, & Sullivan, 2001).

1. *Standardized Subscale (z-score transformation) =*

\[
\frac{(\text{individual subscale score} - \text{mean of general U.S. population})}{\text{Standard Deviation of general U.S. Population}}
\]

2. *Weighted subscales = (standardized subscale} *

\[
\text{PCS or MCS coefficients, respectively)
\]

3. *t-score of PCS or MCS = (sum of 8 all weighted subscales} * 10) + 50

**Aim 1:** To determine which time-matched exercise intervention shows the greatest improvements in 1) HRQoL in addition to 2) Physical and 3) Mental Component Summary scores from the baseline scores to the end of the eight-week intervention.

Descriptive statistics for each variable of interest based on group were compared using a chi squared test or ANOVA test. A linear-mixed effects model was used for repeated measures
of time, group and time-by-group interaction. Between and within group assignment comparisons were made to identify changes of SF-36 scores. The changes in HRQoL subscales and summary scores were reported using the differences of least squares means with 95% confidence intervals. Analyses controlled for age, sex and baseline values of the SF-36 subscales. Exploratory analyses controlled for race, marital status, outside physical activity and energy intake. A statistical significance level of 0.05 was used. SAS software (SAS Institute, Cary, NC) was used for all statistical analyses.

Aim #2: To determine if changes in physical fitness (cardiorespiratory fitness [CRF] and/or muscular strength) from the baseline assessment to the end of the eight-week intervention are associated with changes in HRQoL.

To address the secondary outcome, a regression analysis was completed to see if changes in fitness (CRF/muscular strength), were associated with changes in the SF-36 subscales, summary scores and the overall score with all participants. Muscular strength for one-repetition maximum tests were standardized to find a z-score using the following formula: (value – sex specific mean)/ sex specific standard deviation (SD) (Ruiz et al., 2009, 2008). The sex specific mean and standard deviation were specific to the analyzed study. Baseline and follow-up values were calculated separately for both men and women for both upper and lower body values. For the follow-up values, the mean and standard deviation of the baseline value was used. By standardizing the upper and lower body muscular strength values, total muscular strength, comprised of the mean baseline values of upper and lower body strength and the mean for the follow-up values separately, could be calculated. This allowed for those performing resistance exercise to get the full benefit of working both the upper and lower body while mitigating the impact of the participants performing aerobic exercise who would gain muscular strength in their
lower body. The change in muscular strength was calculated by subtracting the baseline value from the follow-up value. Analyses initially controlled for the change in CRF and muscular strength, age, sex. Exploratory analyses controlled for the change in CRF and muscular strength, age, sex and baseline values of the SF-36 subscales, baseline values of CRF and muscular strength. An exploratory analysis was also performed considering group specific fitness changes. Analyses controlled for the change in CRF or muscular strength, age, sex and baseline values of the SF-36 subscales, baseline values of CRF or muscular strength and group assignment. When the association of changes in CRF and changes in HRQoL were examined, participants assigned to the AET and CET groups were included and when the association was examined for muscular strength, participants assigned to the RET and CET groups were included. A statistical significance level of 0.05 was used. SAS software (SAS Institute, Cary, NC) was used for all statistical analyses.
### Orientation Session
- Informed Consent
- Physical Activity Readiness Questionnaire
- Medical History Questionnaire
- Body Mass Index
- 7-Day Physical Activity Log

### Two Education Sessions
- Benefits of physical activity on CVD & mortality
- Technogym introduction (1RM & treadmill test practice)

### Baseline Assessments
**Day 1**
- Blood Draw (TC, TG, HDL, LDL, & Glucose)
- Bioelectrical Impedance Analysis, Height, Waist, & Skinfold
- Central & Peripheral Blood Pressure & Heart Rate
- 36-Item Short Form Survey

**Day 2**
- Fitness (1 RM & CRF Test)
- Behavioral contract
- Incentive receipt form
- Randomization

### Intervention
- 8 weeks
- 3 days/week for 60 minutes (AET, RET, & CET)
- 3-Day diet at 1st & 8th week
- Pedometer Data for 8 weeks

### Follow-up Assessments
**Day 1**
- Blood Draw (TC, TG, HDL, LDL, & Glucose)
- Bioelectrical Impedance Analysis, Height, Waist, & Skinfold
- Central & Peripheral Blood Pressure & Heart Rate
- 36-Item Short Form Survey

**Day 2**
- Fitness (1 RM & CRF Test)
- Incentive receipt form

### Analysis of Results

*Figure 2. Study Flow - From Orientation to Data Analysis*
CHAPTER 4: RESULTS

A total of 206 potential participants were screened for eligibility in this study. Of those 206 people, there were 69 individuals randomized into one of the four groups: aerobic exercise training (AET), resistance exercise training (RET), a combination of aerobic and resistance exercise training (CET) or a waitlist-control group (CON). Sixty-six participants completed the 8-week intervention. The three who dropped out completed the baseline assessment but did not complete the follow-up. The reasons were: prescription of high blood pressure medication by their physician (n=1), pneumonia (n=1) and muscle discomfort (n=1). An intention-to-treat analysis was used for these participants, so their baseline data was carried forward to replace missing data. Participants’ baseline characteristics are described in Table 4. As shown in the table, no significant differences were found between groups for baseline measurements of age, sex, BMI, marital status, race or ethnicity (all p values >0.05).

<table>
<thead>
<tr>
<th>Table 4. Baseline Characteristics</th>
</tr>
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<tbody>
<tr>
<td>All</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
</tr>
<tr>
<td>Women, No. (%)</td>
</tr>
<tr>
<td>BMI mean (SD), kg/m²</td>
</tr>
</tbody>
</table>

Marital Status No. (%) (n=68) *

| Married | 46 (67.65) | 12 (70.59) | 11 (64.71) | 12 (66.67) | 11 (68.75) | 0.99 |
| Not Married | 22 (32.35) | 5 (29.41) | 6 (35.29) | 6 (33.33) | 5 (31.25) |

Race/Ethnicity, No (%) *

| White, No. (%) | 64 (92.75) | 16 (94.12) | 16 (94.12) | 16 (88.89) | 16 (94.12) | 0.92 |
| Non-White, No. (%) | 5 (7.25) | 1 (5.88) | 1 (5.88) | 2 (11.11) | 1 (5.88) |

Continuous variables were analyzed with one-way ANOVA and categorical variables were analyzed with chi-square tests. * There was one missing data in marital status.
Changes in HRQoL Scores

Changes in Health-Related Quality of Life (HRQoL) total and subscale scores were compared within each group. The results from the linear-mixed effects model comparing the time, group, and time-by group interaction scores are presented in Table 5. The baseline subscale score, age and sex were controlled for in these calculations. The general health subscale was the only subscale that was significantly different at baseline compared to the other groups at baseline. To address the primary aim of the study, comparisons were made between each exercise group and the control group for each subscale, PCS, MCS and the overall score.

Compared to the CON group, the AET group showed significant improvement in vitality (10.3 [0.7, 19.9]) and social functioning (10.3 [0.7, 19.9]) (all p-values <0.05). The CET group significantly improved on health change (19.4 [7.4, 31.5]) compared to the CON group.

The AET group showed significant improvements (mean [95% CI]) post-intervention in vitality (12.1 [5.3, 18.9]) and mental health (4.7 [0.5, 9.0]). The CET group showed significant improvements in vitality (8.3 [1.7, 14.9]), mental health (4.2 [0.1, 8.3]) and general health (8.3 [2.2, 14.5]). The CON group had significant improvements in the mental health subscale (5.41 [1.17, 9.65] (all p-values <0.05). The RET group showed no significant improvements in any of the subscales, although it showed positive trends of improvements in most subscales. However, all exercise groups showed significant improvements from baseline to follow-up on the question of Health Change, which asks, “Compared to one year ago, how would you rate your health in general now?” (CON: 0.0 [-8.6, 8.6], AET: 10.3 [1.7, 18.9], RET: 8.8 [0.2, 17.5], and CET: 19.4 [11.1, 27.8]).

Regarding the summary scores of the PCS and the MCS, the AET group showed significant improvements after exercise in the MCS score (4.0 [0.8, 7.3]) and the CET group
showed significant improvements in both the PCS and MCS scores (3.4 [0.1, 6.8]), (3.6 [0.4, 6.7]), respectively. The RET group also showed improvement, but it was not statistically significant (both p-values >0.05). Although calculating a total score for the SF-36 is not traditionally done using the scoring instructions, (Lins & Carvalho, 2016) found more than 150 published studies that reported a global, total, or overall score for the SF-36 and the majority of the studies calculated an average of the subscales. Based on this, we decided to show the benefits of exercise on HRQoL using the overall SF-36 scores from all the subscales. For the overall score, the CET group was the only group to show significant improvements (6.4 [1.4, 11.4]).

Based on previous studies, we further adjusted for race and marital status and the results were similar. Outside physical activity and diet were also controlled for separately and together with the baseline value of the subscale, age and sex, and again, the interpretation of the results did not change significantly.

**Table 5. Baseline, Follow-up, and Change in Health-Related Quality of Life (SF-36) *

<table>
<thead>
<tr>
<th>Intervention Group</th>
<th>No.</th>
<th>Baseline Value</th>
<th>Follow-up Value</th>
<th>Within-Group Changes</th>
<th>Between-Group Comparison vs. Control Group Changes</th>
<th>Pair-Wise P value</th>
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<td><strong>Physical Functioning</strong></td>
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<tr>
<td>Aerobic</td>
<td>17</td>
<td>82.8 (2.7)</td>
<td>77.8 (2.7)</td>
<td>-5.0 (-12.8, 2.8)</td>
<td>-3.8 (-14.9, 7.2)</td>
<td>0.49</td>
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<tr>
<td>Resistance</td>
<td>17</td>
<td>83.8 (2.7)</td>
<td>86.4 (2.7)</td>
<td>2.7 (-5.2, 10.5)</td>
<td>3.8 (-7.2, 14.9)</td>
<td>0.49</td>
</tr>
<tr>
<td>Combination</td>
<td>18</td>
<td>83.5 (2.6)</td>
<td>86.0 (2.6)</td>
<td>2.5 (-5.1, 10.1)</td>
<td>3.7 (-7.2, 14.6)</td>
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<tr>
<td>Control</td>
<td>17</td>
<td>84.2 (2.7)</td>
<td>83.1 (2.7)</td>
<td>-1.2 (-9.0, 6.6)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Role Limitations Due to Physical Problems</strong></td>
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<tr>
<td>Aerobic</td>
<td>17</td>
<td>80.9 (4.9)</td>
<td>88.3 (4.9)</td>
<td>7.4 (-8.8, 3.5)</td>
<td>7.4 (-15.5, 30.2)</td>
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<td>94.8 (4.9)</td>
<td>13.2 (-2.9, 29.4)</td>
<td>13.2 (-9.6, 36.1)</td>
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<td>80.7 (4.7)</td>
<td>92.5 (4.7)</td>
<td>11.8 (-3.9, 27.5)</td>
<td>11.8 (-10.8, 34.4)</td>
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<td>83.7 (4.9)</td>
<td>0.0 (-16.2, 16.2)</td>
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<td>17</td>
<td>86.5 (4.2)</td>
<td>92.3 (4.2)</td>
<td>5.9 (-7.8, 19.5)</td>
<td>2.0 (-17.3, 21.2)</td>
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<tr>
<td>Resistance</td>
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<td>85.3 (4.2)</td>
<td>91.2 (4.2)</td>
<td>5.9 (-7.8, 19.5)</td>
<td>2.0 (-17.3, 21.2)</td>
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<td>17</td>
<td>54.1 (2.3)</td>
<td>66.2 (2.3)</td>
<td>12.1 (5.3, 18.9)</td>
<td>10.3 (0.7, 19.9)</td>
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<td>6.6 (-2.9, 16.1)</td>
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<tr>
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<td>58.9 (2.3)</td>
<td>1.8 (-5.0, 8.6)</td>
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<td>17</td>
<td>81.1 (1.4)</td>
<td>85.8 (1.4)</td>
<td>4.7 (0.5, 9.0)</td>
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<td>83.5 (1.4)</td>
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<td>-2.8 (-8.8, 3.2)</td>
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<td>85.1 (1.4)</td>
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<td>-1.2 (-7.1, 4.7)</td>
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<td>5.4 (1.2, 9.7)</td>
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<td>97.2 (2.3)</td>
<td>5.2 (-1.7, 12.0)</td>
<td>10.3 (0.7, 19.9)</td>
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<td>6.6 (-3.0, 16.3)</td>
<td>0.18</td>
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<tr>
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<td>91.2 (2.3)</td>
<td>93.2 (2.3)</td>
<td>2.1 (-4.6, 8.7)</td>
<td>7.2 (-2.3, 16.7)</td>
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<td>87.7 (2.3)</td>
<td>-5.2 (-12.0, 1.7)</td>
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<td>81.4 (3.1)</td>
<td>80.1 (3.1)</td>
<td>-1.3 (-10.6, 7.9)</td>
<td>2.13 (-11.0, 15.2)</td>
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<td>78.8 (3.1)</td>
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<td>0.51 (-12.6, 13.6)</td>
<td>0.94</td>
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<td>78.2 (3.0)</td>
<td>83.5 (3.0)</td>
<td>5.3 (-3.7, 14.3)</td>
<td>8.73 (-4.2, 21.6)</td>
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<tr>
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<td>75.9 (3.1)</td>
<td>-3.5 (-12.7, 5.8)</td>
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<td>17</td>
<td>62.7 (2.2)</td>
<td>63.9 (2.2)</td>
<td>1.2 (-5.2, 7.5)</td>
<td>-3.8 (-12.8, 5.2)</td>
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<td>65.7 (2.2)</td>
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<td>-3.2 (-12.21 5.7)</td>
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<td>69.8 (2.1)</td>
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<td>67.4 (2.2)</td>
<td>5.0 (2.2, 14.5)</td>
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<td>47.8 (3.0)</td>
<td>58.1 (3.0)</td>
<td>10.3 (1.7, 18.9)</td>
<td>10.3 (-1.9, 22.5)</td>
<td>0.10</td>
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<td>Resistance</td>
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<td>56.7 (3.0)</td>
<td>8.8 (0.2, 17.5)</td>
<td>8.8 (-3.4, 21.1)</td>
<td>0.15</td>
</tr>
<tr>
<td>Combination</td>
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<td>45.7 (2.9)</td>
<td>65.2 (2.9)</td>
<td>19.4 (11.1, 27.8)</td>
<td>19.4 (7.4, 31.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>46.5 (3.0)</td>
<td>46.5 (3.0)</td>
<td>0.0 (-8.6, 8.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. Continued

<table>
<thead>
<tr>
<th>Physical Component Summary Score (PCS)</th>
<th>Aerobic</th>
<th>17</th>
<th>47.3 (1.1)</th>
<th>47.1 (1.1)</th>
<th>-0.2 (-3.6, 3.2)</th>
<th>-0.1 (-5.0, 4.7)</th>
<th>0.96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>17</td>
<td>48.0 (1.1)</td>
<td>49.7 (1.1)</td>
<td>1.7 (-1.7, 5.1)</td>
<td>1.8 (-3.1, 6.6)</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Combination</td>
<td>18</td>
<td>46.9 (1.1)</td>
<td>50.3 (1.1)</td>
<td><strong>3.4 (0.1, 6.8)</strong></td>
<td>3.5 (-1.3, 8.3)</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>47.6 (1.1)</td>
<td>47.6 (1.1)</td>
<td>-0.1 (-3.5, 3.4)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mental Component Summary Score (MCS)</th>
<th>Aerobic</th>
<th>17</th>
<th>52.4 (1.1)</th>
<th>56.4 (1.1)</th>
<th><strong>4.0 (0.8, 7.3)</strong></th>
<th>2.5 (-2.2, 7.1)</th>
<th>0.29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>17</td>
<td>52.3 (1.1)</td>
<td>54.6 (1.1)</td>
<td>2.3 (-1.0, 5.6)</td>
<td>0.8 (-3.9, 5.4)</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>Combination</td>
<td>18</td>
<td>52.0 (1.0)</td>
<td>55.5 (1.0)</td>
<td><strong>3.6 (0.4, 6.7)</strong></td>
<td>2.0 (-2.6, 6.5)</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>52.5 (1.1)</td>
<td>54.0 (1.1)</td>
<td>1.6 (-1.7, 4.8)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overall Score: Mean of all Subscales</th>
<th>Aerobic</th>
<th>17</th>
<th>76.1 (1.7)</th>
<th>78.6 (1.7)</th>
<th>2.6 (-2.5, 7.7)</th>
<th>1.3 (-5.9, 8.6)</th>
<th>0.72</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>17</td>
<td>77.1 (1.7)</td>
<td>81.2 (1.7)</td>
<td>4.1 (-1.0, 9.2)</td>
<td>2.9 (-4.4, 10.1)</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Combination</td>
<td>18</td>
<td>75.8 (1.7)</td>
<td>82.2 (1.7)</td>
<td><strong>6.4 (1.4, 11.4)</strong></td>
<td>5.2 (-2.0, 12.3)</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>76.7 (1.7)</td>
<td>78.0 (1.7)</td>
<td>1.3 (-3.9, 6.4)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Adjusted for baseline value of each variable, age, and sex

Figure 3. Change in PCS, MCS, and Overall Scores within Each Group.
Scores within each group were calculated from the change of baseline to follow-up scores. The scores were adjusted for the baseline value of each PCS, MCS, and Overall Scores, age, and sex. Error bars indicate 95% Confidence Intervals. *p<0.05 change within groups from baseline to follow-up. There were no significant differences when the exercise groups were compared to the control group.
The mean outside physical activity (e.g. steps per day not during exercise sessions) across the intervention was not significantly different between groups (p=0.66) (Table 6). It also did not change significantly over the course of the intervention as shown in Figure 4. On average, participants wore their pedometer for 14 hours per day over the course of the eight weeks. We also observed no significant difference in average daily energy intake between groups during the 8-weeks of study period based on the data measured in weeks 1 and 8 (p=0.88) (Table 6). Changes in average daily energy intake between week 1 and 8 were also not significantly different between groups (Figure 5).

Table 6. Average Outside Physical Activity and Diet for the Intervention

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>AET</th>
<th>RET</th>
<th>CET</th>
<th>CON</th>
<th>Between Group Differences, p</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>69*</td>
<td>17*</td>
<td>18*</td>
<td>17</td>
<td>17*</td>
<td></td>
</tr>
<tr>
<td>Average Daily Steps</td>
<td>5,429.7</td>
<td>5,661.4</td>
<td>5,391.7</td>
<td>4,997.8</td>
<td>5,693.3</td>
<td>0.66</td>
</tr>
<tr>
<td>Throughout Entire Study</td>
<td>(1,822.8)</td>
<td>(2,056.1)</td>
<td>(2,446.7)</td>
<td>(1,104.4)</td>
<td>(1,506.4)</td>
<td></td>
</tr>
<tr>
<td>Diet, mean (SD), kcal</td>
<td>1,880.6</td>
<td>1,959.9</td>
<td>1,860.6</td>
<td>1,880.0</td>
<td>1,825.8</td>
<td>0.88</td>
</tr>
<tr>
<td>Average Daily Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake in Weeks 1 and</td>
<td>1,840.6</td>
<td>1,959.9</td>
<td>1,860.6</td>
<td>1,880.0</td>
<td>1,825.8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>(462.4)</td>
<td>(447.3)</td>
<td>(465.8)</td>
<td>(539.4)</td>
<td>(411.2)</td>
<td></td>
</tr>
</tbody>
</table>

*A total of 5 people did not report diet data. Two people were in AET, two in the RET, and one was in the CON group.
Figure 4. Average Daily Steps per Week
Over the course of the intervention, the average number of steps per week (excluding steps accumulated during the exercise sessions) was calculated for each of the eight weeks. The figure above shows the outside physical activity recorded by the pedometer was not significantly different each week when comparing the groups throughout the study (each week, p>0.05).

Figure 5. Change in Energy Intake between Week 1 and 8.
Participants energy intake was measured during week one and eight of the study. The change in energy intake was calculated by subtracting the week one data from the week eight data. There was no significant difference in the change in energy intake between groups (p=0.88). Five participants did not report energy intake at either timepoint, so the intention-to-treat analysis could not be used.
The modified, submaximal Balke and Ware Treadmill Test was used to assess cardiorespiratory fitness. For this test, the longer time that a participant goes until they reach 70% of their heart rate reserves (equivalent to 85% heart rate max), the higher their cardiorespiratory fitness. In Table 7, the minutes to completion of this test are shown. The improvement in cardiorespiratory fitness from baseline to follow-up in both the AET and CET group were significant (AET: mean 1.2 [95% CI 0.6, 1.8] and CET: 0.8 [0.3, 1.4]). Compared to the control group, the AET group also had significant improvements in cardiorespiratory fitness (0.9 [0.1,1.7], p= 0.03).

Total muscular strength was defined as the mean of the standardized baseline values of upper and lower body strength and the mean of the standardized follow-up values of upper and lower body strength. In Table 7, the improvement from baseline to follow-up in both the RET and CET group were significant (RET: mean 0.3 [95% CI 0.2, 0.5] and CET: 0.4 [0.2, 0.5]). Compared to the CON group, both the RET and the CET group also had significant improvements in total muscular strength as well (RET: 0.2 [0.0, 0.4], p=0.02 and CET: 0.2 [0.0, 0.4], p=0.02)).

<table>
<thead>
<tr>
<th>Intervention Group</th>
<th>No.</th>
<th>Baseline Value (Mean(SE))</th>
<th>Follow-up Value (Mean(SE))</th>
<th>Within-Group Changes</th>
<th>Between-Group Comparison vs. Control Group Changes</th>
<th>Pair-Wise P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiorespiratory Fitness mean (SE), min*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic</td>
<td>17</td>
<td>5.4 (0.2)</td>
<td>6.6 (0.2)</td>
<td>1.2 (0.6, 1.8)</td>
<td>0.9 (0.1,1.7)</td>
<td>0.03</td>
</tr>
<tr>
<td>Resistance</td>
<td>17</td>
<td>5.4 (0.2)</td>
<td>5.6 (0.2)</td>
<td>0.3 (-0.3, 0.8)</td>
<td>-0.0 (-0.8, 0.8)</td>
<td>0.94</td>
</tr>
<tr>
<td>Combination</td>
<td>18</td>
<td>5.4 (0.2)</td>
<td>6.2 (0.2)</td>
<td><strong>0.8 (0.3, 1.4)</strong></td>
<td>0.5 (-0.3, 1.3)</td>
<td>0.20</td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>5.4 (0.2)</td>
<td>5.7 (0.2)</td>
<td>0.3 (-0.3, 0.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The baseline value is the average of the standardized baseline values of the upper and lower body strength. The follow-up value is the average of the standardized follow-up values of the upper and lower body strength.
Table 7. Continued

<table>
<thead>
<tr>
<th>Total Muscular Strength, mean (SE)†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerobic</strong></td>
</tr>
<tr>
<td><strong>Resistance</strong></td>
</tr>
<tr>
<td><strong>Combination</strong></td>
</tr>
<tr>
<td><strong>Control</strong></td>
</tr>
</tbody>
</table>

Adjusted for baseline value of each, CRF and muscular strength, age, and sex

* The change was calculated by subtracting the baseline value from the follow-up value

† Muscular strength was standardized by finding the mean of both the standardized values of the upper and lower body at baseline and again with the follow-up values.

Regression analyses (Table 8) were performed to see if changes in fitness were associated with changes in SF-36 subscale scores to address the secondary aim of this study. A positive change value for CRF is better because it means that it took the participant longer to complete the treadmill test at follow-up compared to the baseline assessment. A positive change value is also better for the standardized muscular strength value because the participants were able to lift more weight with their upper and lower body at the follow-up assessment compared to what they lifted at baseline. Initially, regression analyses controlled for age, sex, CRF changes and muscular strength changes. To determine independence, the regression analyses controlled for age, sex, respective baseline SF-36 subscale, baseline CRF, and baseline muscular strength, CRF changes and muscular strength changes, respectively. For each one-minute change in CRF, the Health Change is 3.86 points after adjusting for age, sex, baseline CRF level and muscular strength changes. For each one-unit change in standardized muscular strength, the change in the general health subscale is -10.69 points after adjusting for age, sex, baseline muscular strength and changes in CRF, which was unexpected. In general, changes in CRF were positively associated with changes in the SF-36 subscales, while muscular strength changes showed mixed results. Most results were not statistically significant possibly due to smaller changes in both CRF and
muscular strength in a short 8-weeks exercise intervention. When group assignment was considered with the respective fitness changes (e.g. AET and CET with CRF and RET and CET with muscular strength), there were no statistically significant associations with changes in fitness and HRQoL.

Table 8. Regression: Association of Changes in Fitness (CRF/Muscular Strength) and Changes in SF-36 Scores

<table>
<thead>
<tr>
<th>Change in SF-36 Subscale</th>
<th>CRF Changes</th>
<th>Muscular Strength Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>P value</td>
</tr>
<tr>
<td>Physical Functioning</td>
<td>0.71 (-2.76, 4.19)</td>
<td>0.68</td>
</tr>
<tr>
<td>Role limitations due to physical problems</td>
<td>1.54 (-3.56, 6.63)</td>
<td>0.55</td>
</tr>
<tr>
<td>Role limitations due to emotional problems</td>
<td>0.35 (-3.86, 4.57)</td>
<td>0.87</td>
</tr>
<tr>
<td>Vitality</td>
<td>2.38 (-0.16, 4.93)</td>
<td>0.07</td>
</tr>
<tr>
<td>Mental Health</td>
<td>0.34 (-1.37, 2.06)</td>
<td>0.69</td>
</tr>
<tr>
<td>Social Functioning</td>
<td>1.95 (-0.76, 4.66)</td>
<td>0.16</td>
</tr>
<tr>
<td>Bodily Pain</td>
<td>1.67 (-1.92, 5.27)</td>
<td>0.36</td>
</tr>
<tr>
<td>General Health</td>
<td>1.04 (-1.45, 3.53)</td>
<td>0.41</td>
</tr>
<tr>
<td>Health Change</td>
<td>3.86 (0.17, 7.54)</td>
<td>0.04</td>
</tr>
<tr>
<td>PCS</td>
<td>0.36 (-1.06, 1.77)</td>
<td>0.61</td>
</tr>
<tr>
<td>MCS</td>
<td>0.49 (-0.66, 1.65)</td>
<td>0.40</td>
</tr>
<tr>
<td>Total Score</td>
<td>0.98 (-1.14, 3.09)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

* Controlled for age, sex, respective baseline SF-36 subscale, baseline CRF, and baseline Muscular Strength, CRF changes and muscular strength changes, respectively, to determine independence.

In general, exercise attendance was high as shown in Table 9. There were 24 exercise sessions total for 8 weeks and on average, participants only missed one session (attended 23 total sessions 95.8%). The AET group had 97.4% attendance, the RET group 92.8% and the CET group attended 96.8% of the exercise sessions.

Adherence for the intervention was defined as volume of exercise performed divided by prescribed. For aerobic exercise, adherence was calculated by total heart beats. This was
calculated by the duration (minutes) multiplied by intensity (average heart rate in bpm) during each exercise session. To calculate the adherence percentage, the total heart beats performed was divided by the total heart beats prescribed over the course of the intervention. For resistance exercise, adherence was calculated by the total weight lifted. This was calculated by the number of repetitions multiplied by the weight lifted (lbs.) during each exercise session. To calculate the adherence percentage, the total performed weight lifted was divided by the total prescribed weight lifted over the course of the intervention. On average, participants who performed aerobic exercise (AET and CET groups) did 100 ± 6% and worked at an intensity of 114 ± 13%. On average, the participants who performed resistance exercise prescribed (RET and CET groups) completed 100 ± 2% of the sets prescribed and lifted about 99 ± 11% of the total weight lifted.

No group differences for exercise attendance and adherence were statistically significant (p>0.05).

**Table 9. Attendance and Adherence to Exercise Training**

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>AET</th>
<th>RET</th>
<th>CET</th>
<th>CON</th>
<th>Between Group Differences, p</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>49</td>
<td>17</td>
<td>18</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Attendance No. (%)</td>
<td>23.0 (95.8)</td>
<td>23.4 (97.4)</td>
<td>22.3 (92.8)</td>
<td>23.2 (96.8)</td>
<td>0 (0)</td>
<td>0.17</td>
</tr>
<tr>
<td>Attendance Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic % (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Minutes Completed</td>
<td>100.4 (6.3)</td>
<td>101.3 (7.2)</td>
<td>-</td>
<td>99.6 (5.3)</td>
<td>-</td>
<td>0.42</td>
</tr>
<tr>
<td>Total Heart Beats</td>
<td>114.4 (13.2)</td>
<td>116.2 (14.2)</td>
<td>-</td>
<td>112.8 (12.5)</td>
<td>-</td>
<td>0.46</td>
</tr>
<tr>
<td>Resistance % (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Sets Completed</td>
<td>99.6 (1.9)</td>
<td>-</td>
<td>99.3 (2.0)</td>
<td>99.9 (1.9)</td>
<td>-</td>
<td>0.38</td>
</tr>
<tr>
<td>Total Weight Lifted</td>
<td>98.8 (10.8)</td>
<td>-</td>
<td>95.7 (10.5)</td>
<td>101.3 (10.7)</td>
<td>-</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Attendance: The percentage of attended sessions is out of 24 sessions
Adherence considers what the participant performed throughout all the exercise sessions divided by what was prescribed over the course of the intervention.

‘-’ indicates that the group was not prescribed that mode of exercise
CHAPTER 5: SUMMARY AND CONCLUSIONS

The primary aim of this study was to identify which type(s) of exercise improves Health-Related Quality of Life (using SF-36) from baseline to follow-up. This preliminary data suggests that performing a combination of aerobic and resistance exercise for one hour, three times per week significantly improves HRQoL, however, large studies with a longer intervention are required. A combination of aerobic and resistance exercise improved the physical, mental and overall scores of the SF-36. The only other group that significantly improved in any of these summary scales was the aerobic group and they improved the mental component summary score from baseline to follow-up. These are valuable findings because all three exercise groups were prescribed the same volume of exercise (time-matched) that would be performed within one-hour for the average person. This could mean that two times the duration of exercise in the combination group, which was common in earlier studies (Reid et al., 2010; Sillanpää et al., 2012), may not be necessary to improve in the subscales of general health, mental health and vitality, the PCS score, the MCS score and the overall score of the SF-36.

In the six RCTs, which were similar to the current study, more HRQoL improvements were found overall when the participants completed aerobic exercise. For the current study, more HRQoL improvements were found overall when the participants performed a combination of aerobic and resistance exercise (Abrahão et al., 2016; Myers et al., 2013b; Reid et al., 2010; Sillanpää et al., 2012; F. A. C. Wanderley et al., 2015). Besides Reid et al, all the studies showed that AET had significant improvements in the subscales. Sillanpää, Häkkinen, Holviala, & Häkkinen analyzed 204 healthy adults during a 21-week intervention and found significant improvements for the subscales of role limitations due to physical problems, bodily pain and general health for the participants who performed AET. Myers and colleagues found significant
improvements in the subscales of physical functioning, bodily pain, general health, as well as the PCS score during the nine-month intervention for 262 sedentary adults with type 2 diabetes mellitus. Abrahão et al. analyzed 63 adults with systemic lupus erythematosus over twelve-weeks and found significant improvements in physical functioning, role limitations due to physical problems and vitality. Lastly, Wanderley et al. conducted an eight-month study with 75 older adults and found that the AET group had significant improvements in the PCS score and the subscales of general health and mental health. Overall for the current study, aerobic exercise appeared to improve the MCS scores. Similar to other studies, there were significant improvements from baseline to follow-up in the mental health subscale (Wanderley and colleagues), vitality (Abrahão and colleagues) and social functioning. The improvement in vitality and mental health could be due to the fact that there is evidence that exercise improves sleep in adults (Kelley & Kelley, 2017). The current study also found a significant improvement in the MCS score. The AET group had significant improvements in social functioning. Improvements in social functioning have not been previously reported in aerobic exercise group. This improvement could be because the participants worked out with others (e.g., talked with each other during bike exercise) and developed positive relationships with them throughout the eight-weeks.

The present study did not find any significant changes from baseline to follow-up in the RET group, compared to the changes in AET and CET groups. Based on the mixed effects in the regression analysis, CRF improvement in AET group may have a greater impact on improving quality of life more than what muscular strength improvement does in RET group. However, it is also possible that 8-weeks of resistance exercise intervention was not long enough to produce significant improvement in health-related quality of life.
The CET group showed the greatest HRQoL improvements in the current study. Myers et al. also performed a time-matched, nine-month exercise intervention with AET, RET, CET and a CON group in 262 sedentary adults with type 2 diabetes mellitus. They found that the CET group significantly improved the greatest number of the SF-36 subscales (Myers et al., 2013b). Myers et al. found that the AET group significantly improved in the PCS score, the subscales of physical functioning, bodily pain and general health, the RET group significantly improved in the PCS score, the subscales of bodily pain and general health and the CET group improved all of the SF-36 dimensions that the AET and RET group did, and additionally, improved in the vitality subscale. Reid et al. conducted a study with 218 inactive adults with type 2 diabetes mellitus for six-months and did not find any significant improvements for HRQoL with any of the exercise groups (Reid et al., 2010). In this study, the CET group performed the full aerobic and resistance workout which took twice as long to complete compared to the amount of time it took for the AET group and RET group to complete their workouts. Reid and colleagues identified that the CET workout could have required too much time and effort, and therefore, interfered with other life events causing no significant improvements in HRQoL. This may suggest that performing a combination of aerobic and resistance exercise for one-hour, three days a week in the current study may have additional benefits for HRQoL compared to only performing aerobic or resistance exercise alone but performing more than one-hour may not be easily achievable considering a busy daily life for most adults with jobs and many responsibilities. We also would like to note that, in most domains of SF-36, we did not observe a significant improvement in exercise groups compared to CON group, although the AET group showed significant improvements in vitality and social functioning and the CET group showed significant improvement in health change compared to the CON group. This may be also related
to the relative short 8-weeks of exercise intervention and some positive improvements (e.g., mental health and general health subscales) in the SF-36 in the CON group in the current study, which is common in most exercise intervention studies.

In relation to the improvements in CRF and muscular strength, we did not observe many significant improvements in the SF-36, although we found that CRF improvement was associated with positive health changes. This agrees with the findings of Reid et al. who also found no associations between CRF, muscular strength and HRQoL. However, this is not the case for all studies examining fitness and HRQoL. Wanderley et al. tested 75 community dwelling older adults and found that improved CRF over eight months of exercise intervention was associated with improvements in the subscales of physical functioning, role limitations due to physical problems and vitality. Muscular strength was also associated with improvements in role limitations due to physical problems and vitality. The differences between the present study and these results could be related to the differences in the age of the participants (over 60 years old), the length of the intervention (eight-months) and/or the differences in fitness tests. CRF was measured by a 6-minute walk test and muscular strength was measured by a hand-grip test in Wanderley’s study. Sillanpää et al. also found significant associations between CRF which was assessed by a graded exercise test on a cycle ergometer and the general health and bodily pain subscales. Based on these two studies and the present study, changes in CRF may have a bigger influence on changes in HRQoL and may be the reason that in general, changes in CRF were positively associated with changes in the SF-36 subscales (although not significant). CRF has many protective benefits for health. Having a high cardiorespiratory fitness is protective against the progression of prehypertension to hypertension, which is important because of the influence hypertension has on premature cardiovascular disease (Faselis et al., 2012). It has been found
that CRF is associated with mortality and morbidity in both men and women (Carnethon et al., 2003; Chase, Sui, Lee, & Blair, 2009; Kodama et al., 2009; D. Lee, Sui, Church, Lee, & Blair, 2009). The current study was a small, pilot study with a short exercise intervention to investigate the health benefits of different types of exercise but was not designed to investigate the associations of CRF and muscular strength with health-related quality of life. Therefore, further studies with a longer exercise intervention in a large sample is warranted, specifically in the associations between changes in CRF and muscular strength and changes in health-related quality of life.

Strengths of this study included that it was a randomized controlled trial in individuals with elevated blood pressure who were not on blood pressure medication, who were inactive and overweight or obese and were expected to get the most cardiovascular health benefits. Almost half of the U.S. population has hypertension, over two-thirds of the population is overweight or obese and only about 5-10% of US adults meet the physical activity recommendations based on the objectively measured physical activity (American Heart Association News, 2018; Donnelly et al., 2009; Troiano et al., 2008). With these characteristics, the findings of this study can provide some preliminary data to much of the United States population. Technogym allowed us to prescribe exercise to the participants and track their performance objectively, therefore, conclusive data on what the exercise regimen entails for AET, RET or CET be shared to best impact HRQoL even in a short 8-weeks of intervention with more accurately measured exercise adherence data. The exercise prescriptions were time-matched, meaning the volume of exercise would only take each group on average, one-hour to complete in each exercise session. The participants in this study had nearly perfect attendance and had high adherence to the exercise regimen. By having the participants wear a pedometer throughout the study, outside physical
activity was objectively tracked, and no group difference was observed so the changes in health-related quality of life between groups are more likely due to the exercise prescriptions and not because of changes of physical activity outside of the intervention.

The main limitations of this study include the sample size and the duration of the intervention. The smallest sample size of the reviewed studies was 63 adults with largest consisting of 606 adults with different participant characteristics such as different age groups and health conditions. The eight-week intervention may not have been long enough to see changes in health-related quality of life. The eight-week exercise intervention progressively increased in time and intensity since the participants were inactive when they began the study. When looking at meeting the physical activity guidelines, the AET met the aerobic portion of the guidelines during week three, while the RET group met the resistance guidelines during the first week of exercise. The CET group met the aerobic portion of the guidelines during week seven and resistance guidelines during week one. The short training period of the study may not have allowed for the full effects of exercise to be seen, since the participants were meeting the physical activity guidelines at different time periods. The shortest duration of the reviewed studies was twelve-weeks with the longest being twelve-months. Multiple explanatory analyses were performed to see if there were significant improvements in HRQoL post-intervention. Significant improvements could have been a false positive based on random chance. Another limitation of this study is that at baseline, before the intervention started, physical activity was not objectively tracked (e.g., by the pedometer), thus it is still possible that some participants were active and fit before they participated in the study. To be eligible, the participants self-reported that they were not meeting the aerobic and resistance physical activity guidelines, but this was never tracked objectively. A similar limitation is experienced with the diet information.
According to the diet information provided, there were not significant changes during the first and eighth week of the intervention. However, it is still possible that they may have eating differently in the period between week one and eight, which could have possibly affected health-related quality of life and their fitness change during the study.

**Conclusions**

A combination of aerobic and resistance exercise for one hour, three times per week showed significant improvements on the SF-36, specifically for the subscales of general health, mental health and vitality, and in the PCS, MCS and the overall score from baseline to follow-up. Aerobic exercise improved primarily mental health, whereas resistance exercise had minimal improvements. This preliminary data suggests that performing a combination of aerobic and resistance exercise for one hour, three times per week significantly improves for HRQoL. However, more studies with a large sample size and longer intervention are needed.
REFERENCES


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APPENDIX A: IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2217
515-294-4500
FAX 515-294-6667

Date: 7/17/2014
To: Dr. Duck-Chul Lee
251 Foraker Bldg
CC: Lorraine Lanningham-Foster
220 MacKay Hall

From: Office for Responsible Research
Title: Independent and Combined Effects of Aerobic and Resistance Training on Blood Pressure
IRB ID: 14-330

Approval Date: 7/15/2014
Date for Continuing Review: 7/14/2016
Submission Type: New
Review Type: Full Committee

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
APPENDIX B: IRB MODIFICATION APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
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Date: 8/11/2014
To: Dr. Duck-Chul Lee
251 Forker Bldg
CC: Dr. Lorraine Lanningham-Foster
220 MacKay Hall

From: Office for Responsible Research

Title: Independent and Combined Effects of Aerobic and Resistance Training on Blood Pressure

IRB ID: 14-330

Approval Date: 8/8/2014
Date for Continuing Review: 7/14/2016
Submission Type: Modification
Review Type: Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 50), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4506 or IRB@iastate.edu.