THE EFFECTS OF AN EXERCISE PROGRAMME ON HEALTH-RELATED VARIABLES AND MOOD IN SEDENTARY WOMEN

BY

IRENE ELIZABETH GARTSHORE FERGUSON, B.Sc.

being a thesis submitted for the degree of Master of Science (Medical Science) in the University of Glasgow, Department of Physical Education and Sports Science.

OCTOBER 1991

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

TABLE OF CONTENTS

	Page
Title	i
List of Sections	ii
List of Tables	xii
List of Figures	xvi
Acknowledgements	xvii
Summary	xix

Chapter One - Introduction

Section

1. 1. Exercise and Health........................ 1

1. 2. Coronary Heart Disease in Scotland........ 2

1. 3. Coronary Heart Disease Risk Factors....... 3

1. 4. Effects of Physical Activity/Exercise on CHD/CHD Risk Factors........................ 5

1. 5. Women, Exercise and CHD Risk Factors...... 6

1. 6. Other Health Considerations............... 8

1.6.1. Psychological Effects of Exercise......... 8

1.6.2. Exercise and Low Back Pain................ 9

1. 7. Glasgow University Fitness Sessions........ 10

1.8.1. Aim of Study.............................. 11

1.8.2. Research of Hypothesis.................... 11

Chapter Two. Review of Literature.

2. 1. Introduction - Physical Activity, Exercise and Physical Fitness....................... 13

Section 1. - Cardiovascular Fitness.

Page

2.1.1. Aerobic Power.............................. 15

2.1.2. Measurement of V̇O2 Max.................... 16

2.1.2 (a). Direct Measurement of VO2 Max......... 16

2.1.2 (b). Prediction of V̇O2 Max................. 17

2.1.3. Gender Differences in Aerobic Power....... 18

2.1.4. Special Issues for Women.................. 20

2.1.5. Effects of Oral Contraceptives on Exercise Performance................................ 22

2.1.6. Effects of Training the Cardiovascular System..................................... 22

2.1.6 (a). Frequency of Training................. 23

2.1.6 (b). Intensity............................. 24

2.1.6 (c). Duration.............................. 25

2.1.6 (d). Initial Level of Fitness and Effects on V̇O2 Max.............................. 25

2.1.6 (e). Programme Length and Improvements in V̇O2 Max................................. 26

2.1.7. Monitoring the Heart Rate during Exercise. 27

2.1.8. Training and Maximal Oxygen uptake........ 28

2.1.9. Physiological effects of Aerobic dance Training on Women.......................... 29

2. 1. 10. Summary................................ 30

Section Two - Local Muscular Endurance

2. 2. 1. Muscular Endurance..................... 32

2. 2. 2. Local Muscular Endurance and Health.... 34

2. 2. 3. Development of Local Muscular Endurance. 35

2. 2. 4. Gender Differences..................... 37

2. 2. 5. Measurement of Local Muscular endurance. 38

2. 2. 6. Training studies and sit ups........... 39

2. 2. 7. Norm Tables for Abdominal Endurance.... 40

Section Three - Flexibility Page

2. 3. 1. Flexibility........................... 42

2. 3. 2. Development of Flexibility............. 44

2. 3. 3. Gender differences in Flexibility...... 46

2. 3. 4. Health Aspects of Flexibility.......... 46

2. 3. 4 (a). Relaxation......................... 47

2. 3. 4 (b). Low Back Pain...................... 47

2. 3. 4 (c). Relief of Muscular Soreness........ 48

2. 3. 4 (d). Injury Prevention during Physical activity.................. 48

2. 3. 5. Measurement of Flexibility............. 49

2. 3. 6. Training and Flexibility................ 50

2. 3. 7. Norm tables............................ 51

2. 3. 8. Summary................................ 52

Section Four - Body Composition

2. 4. 1. Body Composition........................ 53

2. 4. 2. Gender Differences...................... 53

2. 4. 3. Methods of assessing Body Composition.. 55

2. 4. 3 (a). Hydrostatic weighing............... 55

2. 4. 3 (b). Skinfold Fat Measures.............. 55

2. 4. 3 (c). Other Method of Assessing Body Composition................... 56

2. 4. 4. Energy Balance.......................... 57

2. 4. 5. Basal Metabolic Rate.................... 57

2. 4. 6. Effects of Acute exercise on Basal Metabolic Rate.................... 58

2. 4. 7. Obesity................................. 60

2. 4. 7 (a). Obesity and Diseases................ 61

2. 4. 7 (b). Obesity as a Risk Factor for CHD.... 61

2. 4. 8. The Effect of exercise Training on Energy Balance.......................... 61

Page

2. 4. 9. Effects of Aerobic Training on Body Composition in Non-Obese Subjects...... 62

2. 4. 10. Studies on women...................... 63

2. 4. 11. Studies on Non-Obese Men............... 65

2. 4. 12. Summary................................ 66

Section Five - Blood Pressure

2. 5. 1. Blood Pressure......................... 67

2. 5. 2. Factors Influencing Blood Pressure..... 67

2. 5. 3. Measurement of Blood Pressure.......... 68

2. 5. 4. Hypertension........................... 69

2. 5. 5. Causes of Hypertension................. 69

2. 5. 6. Activity and its Effect on Hypertension 70

2. 5. 6.(a). Epidemiological Studies............ 70

2. 5. 6.(b) Aerobic Training and Blood Pressure. 72

2. 5. 7. Aerobic training on Hypertensive Individuals............... 72

2. 5. 8. Aerobic training on Normotensive Individuals............... 73

2. 5. 9. Gender differences..................... 74

2. 5. 10. Summary............................... 75

Section Six - Blood Lipids and Lipoproteins

2. 6. 1. Blood Lipids and Lipoproteins.......... 76

2. 6. 2. Blood Lipids as Risk Factors in CHD.... 77

2. 6. 3. Physical Fitness and Lipid Levels...... 78

2. 6. 3.(a) Total Cholesterol.................. 78

2. 6. 3.(b) Triglycerides...................... 80

Page

2. 6. 3.(c) Low Density Lipoproteins............ 80

2. 6. 3.(d) High Density Lipoproteins........... 80

2. 6. 4. Gender Differences in Baseline Lipid and Lipoprotein Levels..................... 81

2. 6. 5. Effect of the Menstrual cycle on Serum Lipids................................ 81

2. 6. 6. Oral contraceptive Use and Blood lipids. 82

2. 6. 7. Effects of Training on Lipid and Lipoprotein Levels...................... 83

2. 6. 7.(a) Studies on Men....................... 83

2. 6. 7.(b) Studies on Women..................... 85

2. 6. 8. Gender differences on the Effects of Training on Lipid and Lipoprotein Levels................................ 87

2. 6. 9. Summary............................. 88

Section Seven - Psychological Effects of Exercise

2. 7. Exercise and Mental health............. 89

2. 7. 1. Depression and Anxiety................. 89

2. 7. 2. Classification of Anxiety, Depression and Mood............................... 90

2. 7. 3. Exercise and Depression................ 91

2. 7. 3.(a) Clinical populations................. 91

2. 7. 3.(b) Normal Populations................... 93

2. 7. 4. Effects of Exercise on Mood and State Anxiety.............................. 94

2. 7. 4.(a) Acute Exercise and State Anxiety.... 94

2. 7. 4.(b) Acute Exercise and Mood............. 96

2. 7. 4.(c) Regular Activity and Mood........... 99

2. 7. 4.(d) Effects of Exercise Training on Mood. 100

Page

2. 7. 5. Type-A Behaviour........................ 102

2. 7. 5.(a) Exercise and Type-A Behaviour........ 103

2. 7. 6. Gender differences in the Psychological Effects of Exercise.................... 104

2. 7. 7. Perception of Effort.................. 105

2. 7. 8. Gender differences in the Perception of Effort................................. 108

2. 7. 9. Negative Psychological Effects of exercise........................... 109

2. 7. 10. Summary............................. 110

CHAPTER THREE METHODOLOGY

Section One- Subjects, Design, Measurements and Equipment

3. 1. 1. Subjects............................. 111

3. 1. 2. Study design......................... 111

3. 1. 3. Pilot study.......................... 113

3. 1. 4. Equipment............................ 114

3. 1. 5. Order of Testing..................... 114

Section Two - Methodology Employed

3. 2. 1. Subject Preparation.................. 115

3. 2. 2. Blood Pressure and Resting Heart Rate... 115

3. 2. 3. Body Composition..................... 116

3. 2. 3.(a) Body Composition-Method and Equipment 117

3. 2. 4. Aerobic test......................... 118

3. 2. 4.(a) Aerobic test- Method and Equipment... 119

3. 2. 5. Flexibility.......................... 121

3. 2. 6. Sit-Ups.............................. 122

3. 2. 7. Plasma Cholesterol and Triglycerides... 123

3. 2. 8. Profile of Mood States Questionnaire... 124

Page

3. 2. 9. Training.............................. 124

3. 2. 10. Tobacco Usage........................ 126

3. 2. 11. Food Intake.......................... 127

CHAPTER FOUR RESULTS

4. 1. Introduction.............................. 128

4. 1. 1. Statistical treatment of data.......... 128

4. 2. Subject Characteristics................ 129

4. 2. 1. Description of Subjects................ 130

4. 3. Results................................ 130

4. 3. 1. Results of all Variables at Test 1 and Test 2 for the Exercise and Control groups........................ 131

4. 3. 2. The Exercise Programme.................. 135

4. 3. 2.(a) Adherence............................ 135

4. 3. 2.(b) Traininng Diary Information.......... 135

4. 4. Statistical Analysis of Results....... 139

4. 4. 1. Analysis of Baseline Measures.......... 139

4. 4. 2. Analysis of Changes over the 12 Week Period..................... 139

4. 4. 2.(a) Treatment of data.................... 139

4. 4. 2.(b) Results of the Statistical Analysis.. 139

4. 4. 3. Analysis of Test 2 Results............. 140

CHAPTER FIVE DISCUSSION

Section One - Cardiovascular Fitness

5. 1. 1. Training Effect........................ 162

5. 1. 2. Changes in Resting Heart (pre-exercise) Rate over the 12 week Period........... 163

5. 1. 3. Resting heart Rate - Comparison with Other Studies.......................... 164

Page

5. 1. 4. Control of the Heart Rate at Rest and Factors Affecting Resting Heart Rate. 165

5. 1. 5. Sub-maximal Heart Rate................ 166

5. 1. 6. Sub-maximal Heart Rate - Comparison with Other Studies.................... 168

5. 1. 7. Factors Influencing Sub-maximal Heart Rate............................ 169

5. 1. 8. Possible Mechanisms for the Reduction in Sub-maximal Heart Rate............. 170

5. 1. 8.(a) Central Adaptations................ 170

5. 1. 8.(b) Peripheral Adaptations.......... 172

5. 1. 9. Predicted VO_2 Max...................... 173

5. 1. 10. VO_2 Max - Comparison with other Studies 174

5. 1. 11. Possible Mechanisms for Changes in VO_2 Max.................... 177

5. 1. 12. Summary............................... 179

Section Two - Abdominal Muscle Endurance

5. 2. 1. Sit-ups- Pre and Post-Programme Values. 180

5. 2. 2. Sit- ups- Comparison with Other Studies 181

5. 2. 3. Possible Mechanisms for Improvement in Abdominal Muscle Endurance............. 182

5. 2. 4. Summary............................... 183

Section Three - Flexibility

5. 2. 1. Sit and Reach Scores - Pre and Post - Programme values....................... 185

5. 3. 2. Sit and reach Scores - Comparison with other studies......................... 186

5. 3. 3. Improvements in Flexibility - Possible Mechanisms.................... 186

5. 3. 4. Summary............................... 187

Section Four - Body composition Page

5. 4. 1. Estimated Percentage Body Fat - Baseline Measures.......................... 189

5. 4. 2. Experimental Error.......................... 189

5. 4. 3. Subjects with High Body Fat............ 189

5. 4. 4. Changes in Body Composition............ 190

5. 4. 5. Choice of Skinfold Sites............... 190

5. 4. 6. Energy Balance.......................... 191

5. 4. 7. Body Composition - Comparison With Other studies........................... 193

5. 4. 8. Summary................................. 194

Section Five - Blood Pressure

5. 5. 1. Blood Pressure - Baseline Levels....... 196

5. 5. 2. Blood Pressure - Comparison with other Studies.................................. 196

5. 5. 3. Possible Mechanisms for the Reduction in Blood Pressure....................... 197

5. 5. 4. Reduction in Body weight............... 198

5. 5. 5. Training Stimulus and Changes in Fitness............................. 199

5. 5. 6. Summary................................. 200

Section Six - Plasma Lipids

5. 6. 1. Total Cholesetrol - Baseline levels.... 201

5. 6. 2. Total Cholesetrol - Comparison with other Studies.......................... 202

5. 6. 3. Plasma Triglycerides - Baseline Levels. 202

5. 6. 4. Plasma Triglycerides - Comparison with other Studies.......................... 203

5. 6. 5. Possible Mechanisms and Interactions which cause Decreases in Plasma Triglycerides.......................... 204

5. 6. 6. Weight Loss and Triglycerides.......... 204

5. 6. 7. Summary.................................. 205

Page

Section Seven - Psychological Effects

5. 7. 1. Profile of Mood States - Pre and Post-Training Results........................ 208

5. 7. 1.(a) Composed - Anxious Factor........... 208

5. 7. 1.(b) Agreeable - Hostile Factor.......... 209

5. 7. 1.(c) Elated - Depressed Factor........... 209

5. 7. 1.(d) Cofident - Unsure Factor............ 210

5. 7. 1.(e) Energetic - Tired Factor............ 211

5. 7. 1.(f) Clearheaded - Confused Factor....... 211

5. 7. 2. Summary of Findings..................... 212

5. 7. 3. Mood - Comparison with other Studies... 213

5. 7. 4. Possible Mechanisms for the Psychological Benefits of Exercise..... 214

5. 7. 4.(a) Biochemical Mechanisms.............. 214

5. 7. 4.(b) Physiological Mechanisms............ 216

5. 7. 4.(c) Psychological Mechanisms............ 217

5. 7. 5. Perception of Effort throughtout the Exercise Programme...................... 218

5. 7. 6. Perception of effort - Comparison with other Studies.......................... 219

5. 7. 7. Summary................................ 220

CHAPTER SIX CONCLUSIONS AND RECOMMENDATIONS

6. 1 Conclusions............................ 221

6. 2. Health Benefits from the Exercise Programme.............................. 223

6. 2. 1. Cardiovascular benefits................ 223

6. 2. 2. Body Composition....................... 224

6. 2. 3. Abdominal Endurance and Flexibility... 224

6. 2. 4. Psychological Effects.................. 225

6. 3. Limitations of Study................... 225

Page

6. 4. Recommendations for Future Research... 226

References.................................... 228

APPENDIX A Subject Consent Form................ 258

APPENDIX B Subject Information................. 259

APPENDIX C Smoking Questionnaire.............. 260

APPENDIX D Food frequency Questionnaire....... 261

APPENDIX E Activity Diary..................... 268

APPENDIX F Equipment.......................... 270

APPENDIX G Pilot Study........................ 271

APPENDIX H Results of t-tests on baseline measures............................ 281

APPENDIX J Results of t-tests on Test 2 measures............................ 284

APPENDIX K Initial Telephone Questionnaire.... 287

LIST OF TABLES

TABLE

1. VO_2 Max based on Age and Gender............. 20

2. Norms for Sit-ups by Age Group and Sex...... 41

3. Sit and Reach Norms by Age Groups and Gender 52

4. Percentage Body Fat for Men and Women aged 20 - 49............................. 54

5. Recommended Training Zone for Exercise Prescription................................ 107

6. Mean, Range and Standard Deviation of Physiological Variables for the Exercise Group at Test 1 and Test 2.................. 131

7. Mean, Range and Standard Deviation for Blood Lipids for the Exercise Group at Test 1 and Test 2.................................... 132

8. Mean, Range and Standard Deviation for Mood Factors for the Exercise Group at Test 1 and Test 2.................................... 132

Page

9. Mean, Range and Standard Deviation of Physiological Variables for the Control Group at Test 1 and Test 2.................. 133

10. Mean, Range and Standard Deviation for Blood Lipids for the Control Group at Test 1 and Test 2... 134

11. Mean, Range and Standard Deviation for Mood Factors for the Control Group at Test 1 and Test 2... 134

12. Mean Training Heart Rates, Mean Intensity and Ratings of Perceived Exertion (RPE) for the Exercise Group........................... 136

13. Body Weight (Kg)

A. Paired t-test and 95% Confidence Interval... 141

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 141

14. Sum of Skinfolds (mm)

A. Paired t-test and 95% Confidence Interval... 142

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 142

15. Estimated Percentage Body fat

A. Paired t-test and 95% Confidence Interval... 143

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 143

16. Resting Heart Rate (beats per minute).

A. Paired t-test and 95% Confidence Interval... 144

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 144

17. Systolic Blood Pressure (mm Hg)

A. Paired t-test and 95% Confidence Interval... 145

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 145

18. Diastolic Blood Pressure (mm Hg).

A. Paired t-test and 95% Confidence Interval... 146

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 146

Page

19. Steady State Heart Rate during the 1st Workload

A. Paired t-test and 95% Confidence Interval... 147

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 147

20. Steady State Heart Rate during the 2nd Workload
A. Paired t-test and 95% Confidence Interval... 148

20
B. Two sample t-test of the Differences and 95% Confidence Interval..................... 148

21. Steady State Heart Rate during the Final Workload

A. Paired t-test and 95% Confidence Interval... 149

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 149

22. Estimated $\dot{V}O_2$ Max (Litres/min)

A. Paired t-test and 95% Confidence Interval... 150

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 150

23. Estimated $\dot{V}O_2$ Max, Corrected for Weight (ml/Kg/min)

A. Paired t-test and 95% Confidence Interval... 151
B. Two sample t-test of the Differences and 95% Confidence Interval..................... 151

24. Flexibility - Sit and Reach Test (cm)

A. Paired t-test and 95% Confidence Interval... 152

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 152

25. Abdominal Endurance - Sit-up Test

A. Paired t-test and 95% Confidence Interval... 153

B. Two sample t-test of the Differences and 95% Confidence Interval..................... 153

26. Total Cholesterol

A. Paired t-test and 95% Confidence Interval... 154

26 Page
B. Two sample t-test of the Differences and 95% Confidence Interval.................... 154

27. Plasma Triglycerides

A. Paired t-test and 95% Confidence Interval... 155

B. Two sample t-test of the Differences and 95% Confidence Interval.................... 155

28. Profile of Mood States - Paired t-Tests and 95% Confident intervals

A. Composed - Anxious Factor.................. 156

B. Agreeeable - Hostile Factor................ 156

C. Elated - Depressed Factor.................. 156

D. Confident - Unsure Factor.................. 157

E. Energetic - Tired Factor................... 157

F. Clearheaded - Confused Factor.............. 157

29. Profile of Mood states - Two sample t-Tests of Differences and 95% Confidence Intervals

A. Composed - Anxious Factor.................. 160

B. Agreeeable - Hostile Factor................ 160

C. Elated - Depressed Factor.................. 160

D. Confident - Unsure Factor.................. 161

E. Energetic - Tired Factor................... 161

F. Clearheaded - Confused Factor.............. 161

30. Effects of Aerobic Training on $\dot{V}O_2$ Max in Women........................... 176

31. Effects of Aerobic Training on Body Composition in Women.................. 195

32. Effects of Aerobic Training on Total Cholesterol in Women...................... 206

33. Effects of Aerobic Training on Plasma Triglycerides in Women............... 207

G1. Systolic Blood Pressure (mm Hg) - Pilot Reliability Study............................ 272

G2. Diastolic Blood Pressure (mm Hg) _ Pilot Reliability Study.............................. 273

G3. Resting Heart Rate (beats per minute) _ Pilot Reliability Study..................... 273

G4. Bicep Skinfold (mm) - Pilot Reliability Study.. 274

G5. Tricep Skinfold (mm) - Pilot Reliability Study.. 274

G6. Subscapular Skinfold (mm) - Pilot Reliability Study.............................. 275

G7. Supra-iliac Skinfold (mm) - Pilot Reliability Study.............................. 275

G8. Percentage Body fat - Pilot Reliability Study.. 276

G9. Steady State Heart Rate during the 1st Workload - Pilot Reliability Study.......... 276

G10. Steady State Heart Rate during the 2nd Workload - Pilot Reliability Study.......... 277

G11. Steady State Heart Rate during the Final Workload - Pilot Reliability Study.......... 277

G12. Estimated $\dot{V}O_2$ Max (Litres/minute) - Pilot Reliability Study.............................. 278

G13. Estimated $\dot{V}O_2$ Max (ml/Kg/Minute) -Pilot Reliability Study.............................. 278

G14. Sit and Reach Test - Pilot Reliability Study.. 279

G15. Sit-Up Test - Pilot Reliability Study....... 279

LIST OF FIGURES

FIGURE

1. Strength - LME Continuum............... 35

2. Mean Heart Rates throughout the Exercise Programme...................... 137

3. Mean training RPE throughout the Exercise Programme...................... 138

4. Mean T Scores for the Exercise Group at Test 1 and Test 2.................... 158

5. Mean T Scores for the Control Group at Test 1 and Test 2.................... 159

ACKNOWLEDGEMENTS

This work would not have been possible without assistance from the Carnegie Trust for the Universities of Scotland.

I would like to thank my supervisors, Dr. Nanette Mutrie and Mr.Stan Grant for helpful guidance and assistance before and during this research.

During the write-up stage, when Dr. Mutrie was in the US on sabbatical leave, I had to rely on the assistance of others to relay messages across the Atlantic. I would like to thank Glasgow University Computing Services and Kay Munro, Glasgow University Library for making this possible.

Blood sampling was carried out at Student Health Service, University of Glasgow, thank you to all concerned.

Thanks to the receptionists at the Stevenson Building for receiving calls at the recruitment stage of the study and to all teaching staff who let me monopolise the computer for several months.

I thank my family, in particular, my mother, father and sister, Janice, for giving me support and putting

up with my untidiness during the data collecting and write up stage.

Finally, I would like to thank my dogs, Mandy and Becky for allowing me to take them for walks and creating a distraction from work.

SUMMARY

This study reports on the effects of a thrice weekly exercise programme over a 12 week period on health-related fitness variables, blood lipids and mood in previously sedentary women. Each exercise session consisted of 20 minutes of aerobic exercise at 80% of predicted maximum heart rate, 5 minutes of strength and local muscular endurance and 5 minutes of flexibility exercise.

Twenty two exercisers, age 36.6 ± 9.3 years (range 21 - 48) and 16 controls age 36.4 ± 8.6 years (range 21 - 50) took part in the study. All subjects were assessed, before and after 12 weeks of training, on physiological variables and mood state. A sub-sample of 8 exercise and 9 control subjects had total cholesterol and plasma triglycerides assessed before and after the 12 week training period. T-tests on baseline measures showed that the two groups were not significantly different in any of the variables tested.

Paired t-tests were carried out to assess if either group showed an improvement in any of the variables from Test 1 to Test 2. The exercise group significantly improved in all of the physiological variables except resting (pre-exercise) heart rate which was only of borderline significance and systolic

blood pressure, which did not change significantly. The control group showed a significant reduction in diastolic blood pressure and abdominal endurance. The exercise group significantly improved in all mood factors except clearheaded-confused. Neither group significantly improved total cholesterol or triglycerides.

Two sample t-tests were carried out to determine if the exercise group showed a greater average improvement over the controls in any of the variables tested. The average range of improvement is indicated by 95% Confidence Intervals (CI). The exercise group showed greater average improvement in the following variables : Steady State Heart Rate during 2nd workload, 95% CI (-3.1, -14.8) beats per minute ; Steady State Heart Rate during final workload, 95% CI (-5.3, -15.5) beats per minute ; Estimated $\dot{V}O_2$ max, 95% CI (0.15, 0.41) Litres/minute) and (2.10, 6.16) ml/kg/minute ; Low back/Hamstrings Flexibility 95% CI (2.85, 6.09) cm ; Abdomianal Endurance, 95% CI (2.54, 6.72) repetitions per minute ; Sum of Skinfolds, 95% CI (-2.5, -9.3) mm ; Estimated Percentage Body fat, 95% CI (-1.39, -2.55)% ; Elated-Depressed Mood factor, 95% CI (1.9, 16.4) T score and Energetic-Tired Mood factor, 95% CI (1.6, 14.8) T score.

Previous research has consistently reported that aerobic training can favourably influence resting heart rate, submaximal heart rate and oxygen uptake. The present study found a significantly decrease in submaximal heart rate and an increase in predicted VO_2 max which is consistent with previous findings which conclude that regular aerobic exercise improves the oxygen transport system. In addition, the exercise programme resulted in significant improvements in abdominal muscular endurance and lower back/hamstrings flexibility which may result in improved posture and a decreased risk of low back pain. Increases in elation and perceived energy were evident in exercise subjects. These findings are consistent with previous research.

Two sample t-tests at Test 2 revealed that the exercise group had significantly lower heart rate during submaximal exercise during the ergometer test, higher predicted VO_2 max and higher mean T scores for elated-depressed and energertic-tired mood factors than the control group. These variables show the greatest differences between the groups. Paired t-tests revealed other differences, since there there is more power in within subject tests.

In summary, a 12 week University exercise programme was effective in improving several physiological variables and psychological mood factors related to health and well-being in previously sedentary women.

CHAPTER ONE

INTRODUCTION

1. 1. Exercise and Health

The benefits of exercise have been known for a very long time (Bassey & Fentem, 1981). In the days of our forebearers , survival depended on speed, agility, coordination and stamina. These can only be maintained through regular activity. During the 20 th century, we have seen a tremendous increase in automation, with a huge explosion in the numbers of cars on the road, the invention of the computer, the television, escalators and so on. All of these factors have resulted in a large decline in physical activity during work and leisure. It is probably no coincidence that this last century has seen a rapid increase in diseases such as coronary heart disease and hypertension, psychological disorders such as depression and anxiety, musculo-skeletal deficiences such as osteoporosis, low back pain and obesity. Physical inactivity has been associated with these factors (Pollock Wilmore & Fox 1978; 1984). There is a particularly large association between inactivity and coronary heart disease (Pollock et al, 1978; 1984).

1. 2. Coronary Heart Disease in Scotland

It is now well established that coronary heart disease (CHD) is the greatest single cause of death in the U.K, U.S.A. and other Western countries (Pollock et al 1978 ; 1984; British Heart Foundation, 1990). Each year in Scotland, an average of 18,000 people die from CHD and related causes. This places Scotland at the top of the " CHD Mortality League Table " with more deaths per 100,000 of population than in any other country in the world (Smith, Tunstall-Pedoe, Crombie et al 1989 ; Tunstall-Pedoe, Smith & Crombie 1989). For example, during 1989 in Scotland, 9633 men and 8474 women died as a result of CHD. In relative terms, the death rates per 100,000 were 392 and 322 for men and women respectively (Registrar General for Scotland Annual Report, 1989).

CHD mortality has increased dramtically since World War 2. The rate of increase has followed a similiar pattern in both genders. However, the overall increase has been greater for women. In the period 1940-1942, the death rate per 100,000 among women was 87. Within 10 years, the relative death rate had more than doubled. CHD mortality in women reached a peak in the late 1970's, levelled off and has remained around this level ever since (around 300 deaths per 100,000). This represents an incease of approximately 360% in female mortality from World War 2 to the present.

Among men for the period 1940-1942, there were 119 deaths per 100,000. As with women, the relative death rates had more than doubled in the following 10 years and had reached a peak in the late 1970's, levelled off and have remained around this level to the present time (around 390 deaths per 100,000). These figures represent an increase of approximately 330% in CHD mortality among the Scottish male population since World War 2. (Figures from the Registrar General for Scotland Annual Reports, 1989, 1990).

Clearly since Word War 2, both genders have shown large increases in relative CHD death rates in Scotland. However, the increases for women have been marginally higher. Additionally, a large number of people are admitted to hospital as a result of CHD, placing a substantial burden on the N.H.S. There is a great need to prevent any further increases in the incidence of CHD. Indeed, it would be clearly desirable to see a decrease in CHD mortality in Scotland.

1. 3. Coronary Heart Disease Risk Factors

The actual causes of CHD are still uncertain, but it is thought that a combination of several factors. Smoking and high blood pressure may initiate the atherosclerotic process. The coronary arteries can be narrowed by atherosclerosis, which occurs when fatty subtances are deposited underneath the lining of the artery wall. This causes an accumulation of plaque and scar tissue around the site, causing ischaemia (or a reduction of the blood supply to the heart). As deposition increases, the artery becomes narrower, thus restricting the oxygen supply to the heart. This results in a reduction in the heart's work capacity and a much greater risk of a heart attack.

Although the causes are as yet unspecified, studies have identified a number of risk factors associated with CHD (Pollock et al, 1978; 1984; Sharkey, 1984). These include gender, race, age, heredity, physical inactivity, diabetes, cigarette smoking, diet, hypertension, elevated blood cholesterol,low-density lipoproteins and triglycerides, low levels of high-density lipoproteins and stress. Of these factors, gender, race, heredity and age cannot be altered. The other factors can be altered (Lipids Research Clinics, 1984; Consensus Conference, 1985; Duncan, Farr, Upton et al, 1987).

Three primary risk factors have been identified (Pollock et al 1978). These are high levels of blood cholesterol, hypertension and cigarette smoking. However,the risk factors are inter-related making it difficult to quantify the importance of one risk factor in isolation. It should be emphasised, however, that the chances of developing CHD increases from onefold to almost fourfold when an individual increases the primary risk factors from one to three (Katch & McArdle, 1988; Froelich, Gifford & Dallas Hall 1987).

1. 4. Effects of Physical Activity /Exercise on CHD and CHD Risk Factors

The role of exercise in improving CHD profile is not yet widely acknowledged. A major critisism of the earlier research was the excessive time demands on the participants, despite improvements in CHD risk factors (Pollock et al 1978). If an exercise programme demands too much of a time commitment , adherence levels are likely to be low and any benefits can only be accrued to adherers (Oldridge, 1982). An exercise programme which has less of a time committment is more likely to have a higher adherence level than one which requires more of an individual's time. Moreover, an aerobic training programme which has a prophylactic effect on coronary risk factors has several advantages over pharmacological treatment. These drugs are expensive, can have adverse side effects and are often addictive (Andrews, MacMahon, Austin et al, 1983).

A number of epidemiological studies have confirmed that those who are physically active may gain some protection from CHD (Powell, Thomsom, Casperson et al, 1987). Regular exercise can increase the efficiency of the cardiac function. As the individual becomes fitter, the heart's oxygen demand at a given workload is decreased (Clausen, 1977). Furthermore, several studies have attempted to ascertain the effects of exercise on CHD risk factors (Farrell, 1980; Wood, Haskell, Blair et al, 1983). However, results can be affected by differences in baseline data and confounding factors such as changes in dietary intake, body fat, body weight and tobacco and alcohol usage. However, several well controlled studies have shown that exercise can have beneficial effects on CHD risk factors (Wood et al, 1983; Nelson, Jennings, Esler et al, 1986; Duncan et al, 1987). The British Heart Foundation Working Party Group recently published a report (B.H.F. 1990) which stated that regular exercise increases functional capacity and reduces the risk of some diseases including coronary heart disease. The report also stated that the relative risk of physical inactivity may be greater than originally thought. In fact it is now thought that the risk from physical inactivity may be approaching the risks attributable to the three primary risk factors (B.H.F. 1990).

1. 5. Women, Exercise and CHD Risk Factors

Although evidence shows that men are relatively more at risk and have higher relative mortality rates for CHD, certain risk factors may be present to a greater degree in women in general. It is known that women are less active in terms of sport and exercise than men (Bassey & Fentem, 1981). Furthermore, recent evidence has shown that the numbers of female smokers are increasing, while the numbers of male smokers are decreasing (Brotherston, 1985).

On the contrary, other risk factors are present to a lesser degree in women. Women, in general, tend to have lower levels of total cholesterol, triglycerides low-density lipoproteins and higher levels of high-density lipoproteins at baseline than men due to different circulating sex hormones. (Brownell, Bachorik & Ayerle 1982). Women also have a higher lipolytic enzyme activity , resulting in a more efficient rate of fat metabolism, which can influence the levels of blood lipids. However, these favourable blood lipid profiles which women in general possess, can be negated by the use of oral contraceptives.The effects depend on the type and combination of steroids in the pill. Some preparations cause increases in low-density lipoproteins and a decrease in high-density lipoproteins, while others affect only low-density lipoproteins.

From the limited research carried out on women, it is found that women respond in a similar way to men to a training stimulus with regard to changes in aerobic power (Pollock et al 1978; 1984), body composition

(Katch & McArdle, 1988) and muscular strength and endurance (Pollock et al 1978; 1984). However, because of the difference in baseline levels of blood lipids and the hormonal influences on the lipids, the effects of exercise on this coronary risk factor may not be the same as those found for men. Recently, however, an exercise programme demonstrated favourable changes in lipid levels in women (Hardman & Hudson, 1991).

1. 6. Other Health Considerations

1. 6. 1. Psychological Effects of Exercise

Less well documented, but equally important, are the psychological effects of exercise or physical activity. Exercise has been associated with decreases in depression (McCann & Holmes, 1984) and anxiety (Raglin & Morgan, 1987), increases in mood (Dyer & Crouch, 1988) and self esteem (Plummer & Koh, 1987) and feelings of well-being (Ross & Hayes, 1986; Moses, Steptoe, Edwards et al, 1989). It has also been suggested that regular activity will reduce reactivity to stress (Roth & Holmes, 1985). Although psychological factors have not been identified as primary risk factors, it has been suggested that Type-A personalities are more prone to CHD (Mathews & Hayes, 1984). However, the evidence for exercise as a beneficial influence on type-A personality is limited (Blumenthal et al, 1980; Gikk, Price & Freedman 1986).

Nevertheless, mental health status remains an important variable in any research concerning exercise and CHD, since adherence to exercise programmes may depend on exercisers perceiving the benefits. Indeed, most surveys of exercisers show that exercise makes participants "feel better" (Berger & Owen, 1983; Ross & Hayes, 1988; Moses, Steptoe, Matthews et al, 1989).

1. 6. 2. Exercise and Low Back Pain

Back pain affects 80% of people in Britain at some time or other, costing the country more than 30 million lost working days and the NHS more than 150 million pounds each year (National Back pain Association, 1988). Of this number, many individuals suffer low back pain because of musculo-skeletal deficiences, stress or tension or possibly poor posture and weakness, particularly in the trunk area (Addison & Schultz, 1980). Exercise can play a role in the treatment and prevention of back pain. Although opinions are divided regarding the etiology of back pain, there is strong evidence which supports the need for adequate trunk mobility (Alter, 1988). Farfan (1978) suggests that flexibility of the lumbar spine provides a mechanical advantage for function and efficiency.

These factors should be considered when designing an exercise programme which is geared towards promotion of health and fitness. A well designed exercise session should contain a session which focusses specifically on trunk strength and flexibility.

1. 7. Glasgow University Group Fitness Sessions

The Department of Physical Education and Sports science at the University of Glasgow runs an extensive exercise programme which is open to staff and students at the University and to members of the general public (Kelvin Hall Sessions). Over 2,000 people take part in these sessions weekly and 70% of this number are female. These indoor sessions provide an opportunity for regular participation in a health related activity which contains aerobic, muscular strength and endurance and flexibility components.

The classes are of 30 minutes duration and are organised as follows : Warm up and aerobic section (20 minutes); Local muscle conditioning section (5 minutes) and Flexibilty section (5 minutes). The two types of session offered in the present study were : Tune-up, where exercise is performed with music in the background and Popmobility, where exercise is performed in rhythm to music.

A recent study (Grant,1989 [Unpublished Masters Thesis]) based on Tune-up sessions demonstrated significant health benefits for sedentary men who underwent a 10 week training programme. Participants were given an opportunity to monitor their own activity by taking their own pulse rates. They were encouraged to set their own personal goals and work within their own target heart rate zones.

It is therefore desirable to carry out a similar study to assess the effects the University sessions on health-related variables in women in order to assess if these sessions give similar health benefits to female participants. A parallel study in women will allow comparison with the male study. It is necessary to assess both men and women since the University sessions are mixed sessions.

1. 8. 1. Aim of study

The aim of the study was to assess the effects of a 30 minute exercise session carried out 3 times per week at an intensity of between 50% and 85% of maximum heart rate reserve, for a period of 12 weeks on physiological and psychological variables and blood cholesterol and triglycerides in previously sedentary pre-menopausal women. An age-matched, non-exercising group was used to control the study.

1. 8. 2. Research Hypothesis

The hypothesis is that a 12 week programme, as described above, can improve resting heart rate, blood pressure, aerobic fitness, abdominal endurance, hamstings/lower back flexibility, mood and blood lipid profile in previously sedentary, pre-menopausal women, compared with a matched group of non-exercising controls.

CHAPTER TWO

REVIEW OF LITERATURE

2. 1. Introduction - Physical Activity, Exercise and Physical Fitness

It is necessary to distinguish between physical activity, exercise and physical fitness. These terms, when consulting the literature, are often used interchangeably. However, a report by Caspersen, Powell & Christenson (1985) attempts to separate the three concepts. Physical activity is defined as " any bodily movement that results in energy expenditure ". The energy expenditure may be occupational, sports, conditioning, household or other activities. Exercise is defined as being a subset of physical activity which is " planned , structured and repetitive and has as a final or intermediate objective the improvement or maintenance of physical fitness ". Physical fitness is " a set of attributes that are either health- or skill- related".

Fitness is a concept which can be subdivided into several components (Caspersen et al, 1985; Pate, 1988). These components include cardiovascular endurance, muscular strength, muscular endurance, flexibility, body composition, speed, power and agility. Components considered to be important for health are aerobic endurance, muscular strength, muscular endurance, flexibility and body composition (Sharkey, 1984; Caspersen et al, 1985; Pate, 1988). Each of these factors have a role to play in the attainment and maintenance of good health and fitness. Each component of fitness requires a specific type of training regime. Although all components are important to health and fitness, aerobic endurance is the component which has the greatest association with coronary heart disease prevention (Fentem & Bassey, 1981).

2. 1. 1. Aerobic Power

Aerobic power or maximal oxygen uptake ($\dot{V}O_2$ max) is the maximum amount of oxygen an individual can extract from inspired air during exercise (Astrand & Rodahl, 1977). The oxygen is required to supply the working muscles. $\dot{V}O_2$ max is limited mainly by the cardiovascular system, although it is reported that in some highly trained endurance athletes $\dot{V}O_2$ max is limited by the respiratory system under certain conditions (Dempsey, Hanson & Henderson, 1984). Maximal oxygen uptake is a product of the cardiac output and the ability of the muscles and tissues to extract oxygen. Cardiac output is the volume of blood pumped by the heart in one minute. This volume depends on the stroke volume (the amount of blood ejected by the ventricles per beat) and the heart rate in beats per minute. Cardiac output is the product of the stroke volume and heart rate. By measuring the difference in oxygen content between the arterial and the venous blood (a-vO_2 Diff) an individual's ability to extract oxygen can be assessed. The greater the amount of oxygen extracted, the greater the a-vO_2 Diff is (Fox & Matthews, 1981). Maximal oxygen uptake is the product of cardiac output * a-vO_2 Diff. Stroke volume is thought to be the most important component of cardiac output with regard to $\dot{V}O_2$ max, since maximal heart rate is fixed, as elite endurance athletes have high stroke volumes (Fox & Matthews, 1981; Astrand & Rodahl, 1986). Another factor which can influence $\dot{V}O_2$ max is the level of haemoglobin in the blood. Haemoglobin transports oxygen to the metabolising tissues and low levels will limit this transport. Mean values for haemoglobin concentration in women and men respectively are 13.7 and 15.8 g/100 ml of blood (Brooks & Fahey, 1984). The oxygen content of the blood is around 16.7 ml of oxygen/100 ml blood for women and 19.2 ml of oxygen/100 ml blood for men (Brooks & Fahey, 1984).

2. 1. 2. Measurement of $\dot{V}O_2$ max

A maximal oxygen uptake test is the most accurate method of measuring the ability of the oxygen transport system to uptake oxygen. Oxygen uptake can be measured either directly or indirectly (Lamb, 1978; Astrand & Rodahl, 1986).

2. 1. 2. (a) Direct Measurements

Direct measurement of $\dot{V}O_2$ max is carried out by collecting and analysing expired air from subjects who are exercising at maximal effort, since oxygen uptake equals the amount of oxygen inhaled minus the amount exhaled. To exercise maximally, subjects have to be highly motivated (Lamb, 1978). Subjects who are not highly motivated tend to give up before reaching maximal effort. For this reason a maximal test is not always appropriate for sedentary subjects (Hammond & Froelicher, 1984)

2. 1. 2. (b) Prediction of $\dot{V}O_2$ max

For reasons mentioned above, it was necessary to develop other more convenient methods of measuring maximal oxygen uptake. $\dot{V}O_2$ max can be predicted if certain assumptions are made. One assumption is that there is a linear relationship between heart rate and oxygen uptake during exercise. That is, as the workload increases , the heart rate increases linearly (Astrand & Rodahl, 1986). In earlier work, Astrand (1954) found that heart rate and oxygen uptake are linear over a heart rate range of 120-170 beats per minute. An individual's heart rate at a given submaximal workload will be associated with a certain oxygen uptake (Astrand & Rodahl, 1977; 1986). The subject's maximum heart rate has to be known or estimated. Maximum heart rate can be measured or estimated by subtracting the subject's age from 220 (Karvonen, 1957). This formula, however is only accurate to plus or minus 10% (Wilmore, 1977), so an individual's estimated maximum heart rate may be over or under- estimated by as much as 20 beats per minute.

To directly measure, or predict maximal oxygen uptake, the subject must reach steady state. Steady state is reached when the oxygen uptake corresponds to the oxygen requirements of the tissues (Astrand & Rodahl, 1977). Using a steady state approach serves to standardise conditions. This is necessary for any repeat assessments.

2. 1. 3. Gender Differences in Aerobic Power

Women when compared to men have a higher cardiac output while exercising at the same oxygen consumption (Astrand & Rodahl, 1986). This may be attributed to a lower oxygen carrying capacity due to lower haemoglobin levels in women or a difference in the function of the heart itself. Resting stroke volume for untrained males is normally between 70 -90 ml per beat with maximal values increasing to about 100 - 120 ml per beat. Endurance trained men have stroke volumes of 100 - 120 ml and 150 - 170 ml for resting and maximal conditions respectively (Fox & Matthews, 1984). For women, the values for stroke volume are normally lower than for men under all conditions. For example, untrained woman have values of between 50 and 70 ml increasing to 70 to 90 ml with training. Maximal values for stroke volume in untrained females are normally between 80 and 100ml and between 100 and 120 ml for trained women. Due to the smaller size of the female heart, the stroke volume at the same workload will be lower for a woman compared with a man. These factors imply that women will generally have lower

$\dot{V}O_2$max values than men. Expressed in absolute terms, the difference in $\dot{V}O_2$max between women and men averages 51.5 %. When expressed relative to body weight and lean body, the differences are reduced to 18.6% and 9% respectively. (Lenskyj, 1988). However, there is considerable overlap between the genders. Table 1 shows ranges of $\dot{V}O_2$ max values for men and women based on an American population. Data for trained and untrained individuals were included. (Katch & McArdle, 1986). This Table highlights the overlap between the genders. That is, trained women have much higher $\dot{V}O_2$ max values than untrained, or less active males of comparable age. However, these values have to be viewed with caution as classification of $\dot{V}O_2$ max is highly subjective and can be influenced by genetic, environmental and motivational factors.

There are certain sports which require very high aerobic fitness. These sports include long distance running (including ultra-distances), cross-country skiing and triathlons. Very high values of $\dot{V}O_2$ max have been reported in elite women who compete in these activities (Katch & McArdle, 1988). For example $\dot{V}O_2$ max values approaching 70 ml/kg.min have been recorded in female cross country skiers. This figure exceeds values recorded for males in many sports including distance swimming, tennis and gymnastics.

Table 1. $\dot{V}O_2$ max based on age and gender (ml/Kg.min).

AGE	LOW	FAIR	AVERAGE	GOOD	HIGH
20-29 M	37	38-41	42-50	51-55	56+
F	28	29-34	35-40	41-46	47+
30-39 M	33	34-37	38-42	43-50	51+
F	27	28-33	34-38	39-45	46+
40-49 M	29	30-35	36-40	41-46	47+
F	25	26-32	30-37	38-43	44+

Adapted from Katch & McArdle (1988)

2. 1. 4. Special Issues for Women

Several investigations on the menstrual cycle and its effect on physical working capacity have been documented (Doolittle & Engebretson, 1971; Wearing et al, 1972; Doskin, Kozeeva, Lisitskaya et al, 1979; De-Bruyn-Prevost, Masset & Stubois , 1984; Eston & Burke 1984; Bale & Davies, 1983; Brooks-Gunn, 1986).
Eston & Burke (1984) studied the effects of the menstrual cycle on several variables including heart rate, perceived exertion and VO_2 in response to constant load exercise. These variables were tested on 21 subjects during the follicular, luteal, premenstrual and menstrual phases of the cycle. $\dot{V}O2$ max was determined and then subjects exercised at intensities of approximately 70 and 90 % $\dot{V}O_2$max. Post hoc comparisons revealed higher weight in the premenstrual phase when compared to the others.

However, there were no significant differences in perceived exertion, heart rate or $\dot{V}O_2$ among the four phases of the menstrual cycle at 70 % and 90 % of $\dot{V}O_2max$. De-Bruyn-Prevost et al (1984) administered aerobic and anaerobic tests at three different stages of the menstrual cycle (menstrual, pre-menstrual and ovulatory stages)in women aged 18-25. Tests were carried out on a bicycle ergometer. PWC_{170}, $\dot{V}O2MAX$ and lactic acid levels were not significantly different between the three stages of the cycle. Wells (1991) has reviewed a large number of studies on the menstrual and performance in physical activities. It would appear that in most individuals, cycle phase has no effect on performance. However, Brookes-Gunn et al (1986) suggested that cycle phase can affect swim times in adolescent sprint swimmers. In this study, swimmers were studied for 12 weeks and it was found that the fastest times occurred during menstruation and the slowest during pre-menses.Similarly, Doskin et al (1981) found that there were fluctuations in performance involving balance during the menstrual cycle in gymnasts.

Although there are conflicting results regarding the menstrual cycle and exercise and sport performance, most of the literature suggests that in women who do not suffer dysmenorrhoea, cycle phase does not affect performance (Eston, 1984).

2. 1. 5. Effects of Oral Contraceptives on Exercise Performance

Oral contraceptives tend to have unfavourable effects on exercise performance (Dagget, Davies & Boobis (1983) ; Wirth & Lohman, 1982). Dagget et al, 1983 reported that maximal oxygen uptake was significantly decreased in active women during oral contraceptive use. Muscle biopsies revealed significantly lower levels of oxidative enzymes. When the women stopped using the contraceptives, the values returned to normal. Unfavourable changes in isometric strength have been reported following oral contraceptive use (Wirth & Lohman, 1982). It would seem that athletic women should avoid OC use when competing.

2. 1. 6. Effects of Training on the Cardiovascular System

The effects that training has on an individual's cardiovascular fitness depends on various factors. These factors include frequency, intensity and duration of training, mode of exercise, the length of the training programme, the initial fitness of the individual and the age of the individual (ACSM,1990).

The frequency, duration and intensity of the exercise are dependent on each other and the interactions between these factors dictate the magnitude of change in cardiorespiratory fitness. However, taken collectively, all can contribute to positive changes in $\dot{V}O_2$ max.

2. 1. 6. (a) Frequency of Training

The omptimal frequency of training depends on the level of fitness of the individual. Less fit individuals can benefit from two days training per week (Fox, 1979), whereas fitter individuals require a greater stimulus to improve their fitness. Wenger & Bell (1986) suggested that those in a low fit category should exercise between 2 and 6 times per week, but 2 sessions per week would not be a sufficient stimulus for fitter individuals. The more often an individual trains for a specific activity, the better the improvement in his/her fitness (Wenger & Bell,1986). Hickson & Rosenkoetter (1981) and Gettman, Pollock, Durstine et al (1977) have shown that as frequency of aerobic activity increases, so does $\dot{V}O_2$ max. However, when other factors such as intensity and duration are considered, the frequency of training can be reduced. That is, if the intensity and/or the duration of activity is increased the frequency can be reduced to obtain the same net effect.

2. 1. 6. (b) Intensity of Training

In order to improve aerobic fitness, there has to be a minimum stimulus. In their recent guidelines, the

American College of Sports Medicine (ACSM, 1990) recommend that a minimum intensity of 50% of $\dot{V}O_2$ max, 50% of maximum heart rate reserve or 60% of maximum heart rate is required to improve $\dot{V}O_2$ max. However, other researchers suggest that improvements can occur at even lower intensities in older subjects (Badenhop,Cleary,Schaap et al,1983).

A common method of determining exercise intensity is by using the Karvonen Formula. Karvonen et al (1957) found that aerobic power improved at intensities of 60% of heart rate reserve (HRR) and greater. Heart rate reserve is calculated from resting heart rate and maximum heart rate (or an estimate of maximum heart rate). 60% of HRR is obtained by subtracting resting heart rate from maximum heart rate , taking 60% of this and then adding resting heart rate to this figure. Measuring heart rate during exercise is a practical way for subjects to monitor their intensity.

The magnitude of change in $\dot{V}O_2$ max increases as intensity increases towards 100% of $\dot{V}O_2$ max (Wenger & Bell, 1986). If intensity exceeds 100% VO_2 2max, the magnitude of change decreases (Faria, 1970). The minimum intensity required to evoke this increase in $\dot{V}O_2$ max has been found to be around 50 % of $\dot{V}O_2$ max (Gaesser & Rich, 1984).

2. 1. 6. (c) Duration

Wenger & Bell (1986) and ACSM (1990) suggest that to promote improvement in aerobic fitness, each exercise session should last for a minimum of 15 minutes. Longer sessions are required for fitter indivuals, however Milesis et al (1976) reported that with novice exercisers, risk of injury increases as sessions approach 30 minutes or more in duration. However,low intensity exercise can be sustained over longer periods of time than a high intensity session highlighting the link between intensity and duration. Additionally, either long duration/low intensity exercise or shorter duration/high intensity exercise requires adequate recovery, so better quality exercise would result by reducing the frequency. It can be seen that intensity , frequency and duration have to be considered together when designing a training programme (Wenger & Bell, 1986).

2. 1. 6. (d) Initial Level of Fitness and Effects on $\dot{V}O_2$ max

Changes in $\dot{V}O_2$ max are related to initial level of fitness. This is an inverse relationship. That is , the lower the initial level of fitness, the greater the improvement in $\dot{V}O_2$ max (Wenger & McNab,1985). As fitness improves the change in $\dot{V}O_2$ max with training decreases, even if intensity and duration are increased. Sedentary individuals do not require a high stimulus to improve their fitness.

2. 1. 6. (e) Programme Length and Improvements in $\dot{V}O_2$ max

It has been suggested that improvements in $\dot{V}O_2$ max occur linearly up to 10 -11 weeks in a training programme. After this period, improvement rate levels off (Wenger & Bell, 1986) This appears to be true for all fitness levels, intensities and durations of exercise. Hickson (1981) suggests that maximum adaptation in $\dot{V}O_2$ max occurs after 3 weeks of training when training variables remain constant. Cunningham (1979) showed a significant increase in a-vO_2 Diff after 8 weeks of training. A further 4 weeks showed only a very slight improvement in this increased value. However, although $\dot{V}O_2$ max may level off in time, probably due to genetic influences, performance in an activity can still improve. This occurs due to training-induced changes in the onset of blood lactate accumulation (OBLA). [OBLA is usually taken as a blood lactate concentration of 4 mmol/L]. A highly trained individual can exercise at a higher percentage of VO_2 max for longer periods of time before OBLA, compared with an untrained individual (Lamb, 1984). Thus, monitoring blood lactate during sub-maximal cycle tests may be a better indicator of changes in training status than $\dot{V}O_2$ max values (Lamb, 1984).There does seem to be any consensus amongst researchers regarding programme length and improvements in $\dot{V}O_2$ max.

The American College of Sports Medicine (ACSM) have recently published guidelines on the recommended quality and quantity for increasing cardiorespiratory and muscular fitness in healthy adults (ACSM, 1990). This statement replaces an earlier statement (ACSM,1978).The recommended frequency is 3-5 days per week; the recommended intensity is between 50-85 % of an individual's heart rate reserve (HRR) or $\dot{V}O_2$ max or 60-90 % of maximum heart rate ; the recommended duration per session is between 20-60 minutes. To develop cardiorespiratory endurance, the mode of activity should use large muscle groups in a rhythmic continuous manner which can be maintained for the duration, intensity and duration (ACSM, 1990). The main difference between the 1990 statement and the 1978 is the minimum threshold exercise intensity has changed from 60 % of $\dot{V}O_2$ max to 50% of $\dot{V}O_2$ max or heart rate reserve.

2. 1. 7. Monitoring Heart Rate during Exercise

In order to check if exercise is of the required intensity, heart rate is often measured during a training session. Although heart rate can decrease fairly rapidly when an activity is stopped, training intensity is often checked by measuring pulse rates in 10 - 15 second breaks during activity (at least 15 minutes into the activity to ensure that subjects have reached steady state).This particular method is used extensively in Glasgow University fitness sessions and work by Grant (1989) and Armstrong & Sutherland (1990) have confirmed that is appropriate for monitoring intensity of exercise. This method has proved sufficiently accurately for subjects in work by Pollock et al (1984), if heart rate was checked within 12-14 seconds of cessation of exercise. Other investigators have reported similar findings (McArdle et al, 1969). Pollock (1984) suggests that a 15 second count is an accurate method of measuring heart rate and, hence, intensity.

2. 1. 8. Training and Maximal Oxygen Uptake

Numerous studies have assessed the effectiveness of training programmes on maximal oxygen uptake using different modes of activity (e.g. running, swimming, cycling and general "aerobic" activities). The training mode most extensively used with women is aerobic dance or "aerobics". Aerobic dance may be defined as a combination of various dance movements and calisthenics-type exercises including running, hopping and jumping (Garrick & Requa,1986). Foster, (1975) assessed the physiological requirements of aerobic dancing and concluded that the relative intensity of the exercise was equivalent to running at a 12 minute per mile pace. Peak intensity of some individuals in this study (Foster, 1975) could be comparable to running a 9.5 minute per mile pace.

Popmobility sessions at Glasgow University are similar to aerobic dance in the type of movements used. However, "Popmobility" involves less choreography and more jogging/running movements.

2. 1. 9. Physiological Effects of Aerobic Dance Training in Women

Various investigations on the cardiorespiratory effects of aerobic dancing have recently been undertaken (Rockefeller & Burke, 1979; Wynne et al, 1980; Frey, Doerr, Laubach et al, 1982; Vaccaro & Clinton, 1983; Cearly, Moffat & Knutzen, 1984; Williams & Morton, 1986; Williford, Blessing, Barksdale et al, 1988; McCord, Nichols & Patterson, 1989). All of these studies have involved short programme length of up to 3 months duration. Rockefeller & Burke (1979) studied the effects of a 10 week programme carried out 3 times per week on 19 young untrained women. The exercise resulted in significant beneficial changes in $\dot{V}O_2$ max, pulmonary ventilation, sub-maximal heart rate and perceived exertion without changes in body composition. Williams & Morton (1986) compared previously sedentary women who underwent 12 weeks of aerobic dance training (3 times per week for 45 minutes at 85 % of maximum heart rate) with sedentary controls. Values for selected cardiorespiratory responses showed that this form of exercise produced training effects in the exercise group. Improvements were found for oxygen pulse, ventilation rate, $\dot{V}O_2$ max and perceived exertion in response to sub-maximal exercise. Similarly, Wiliford et al (1988) and Vaccaro & Clinton (1983) showed that aerobic dance carried out 3 times per week at appropriate intensities and duration can improve $\dot{V}O2$ max. The exercise group in the study by Wiliford et al showed a mean improvement of 12 % following 10 weeks of training at 60-90% of $\dot{V}O_2$ max for 30 minutes per session. Controls showed no significant improvements. Vaccaro & Clinton showed that 10 weeks of aerobic dance training significantly increased $\dot{V}O_2$ max. However there was no control group in this study.

In an attempt to decrease injury during aerobic dance, low impact aerobics has recently been developed. In this type of exercise, one foot remains in contact with the floor at all times. McCord et al (1989) examined the effects of a 12 week programme of low impact aerobics. Post-test results showed a small improvement (7 %) in $\dot{V}O_2$ max.

Aerobic dance-type activity seems to be a suitable method of improving aerobic power in women. However, lower intensities do not improve $\dot{V}O_2$ max as well as higher intensities. To maximise improvement, intensity should be high. However, previously sedentary individuals can benefit from low impact exercise, initially.

2. 1. 10. Summary

Aerobic fitness is the most important component of fitness with regard to the prevention of cardiovascular diseases such as coronary heart disease. The measure of aerobic fitness is $\dot{V}O_2$ max. $\dot{V}O_2$ max can be increased by training using the appropriate mode of exercise at the appropriate intensity, frequency and duration.

Section 2 Local Muscular Endurance

2. 2. 1. Muscular Endurance

Muscular strength may be defined as the maximum force a muscle group can exert against a resistance (Fox & Mathews, 1981). Muscular endurance, on the other hand is the ability of a muscle or muscle group to, perform repeated contractions against a submaximal load over a period of time [isotonic] or as a sustained contraction [isometric] (Fox & Mathews, 1981).

It is generally accepted that absolute muscular endurance is best increased through training muscles that emphasises high repetitions and relatively low resistance (Watson, 1983). However, there is a high correlation between strength and absolute muscular endurance (Wilmore, 1982). This would suggest that programmes which are designed to improve strength should also provide some improvement in muscular endurance. Therefore strength appears to be a major determinant of muscular endurance. Other factors which influence muscular endurance are local circulation in the muscles and the various enzymes within the muscles.

There are several energy systems which can supply the ATP essential for muscular contraction. Immediate energy sources are creatine phosphate (CP), adenosine triphosphate (ATP) which are stored within the muscle (Brooks & Fahey, 1984 ; Wilmore, 1982). Energy is also supplied from the breakdown of glucose (glycolysis), free fatty acids and proteins.

The CP-ATP system supplies energy when CP and ATP are broken down. Oxygen is not required, so it is an anaerobic process. The advantages of this energy system is that it is immediately available and can provide the muscle with a large amount of energy per unit of time (Fleck & Kraemer, 1987). However, the stores of creatine phosphate and ATP within the muscle are limited and are depleted within 15-30 seconds of all- out muscular activity (Astrand & Rodahl, 1986).

ATP is also supplied from glycolysis. In the absense of oxygen, energy is released when glucose (from muscle glycogen) is broken down to pyruvate which is then transformed to lactic acid (Fleck & Kraemer, 1987). The progressive build up of lactic acid will, however, cause the muscles to fatigue. When lactic acid accumulation becomes excessive, it can eventually affect nerve endings and cause pain. Additionally, as build up progresses, the interior of the muscle cell becomes more acidic (increase in hydrogen ions). The increase in hydrogen ions and resultant decrease in pH will inhibit glycolysis by reducing the activity of phosphofructokinase [an enzyme involved in glycolysis]

(Trivedi & Danforth, 1966) and can reduce the binding of calcium ions to troponin, thus reducing the contractile properties of the muscle (Fleck & Kraemer, 1987).

In the presence of oxygen, pyruvate enters into the Krebs' cycle reactions, producing more ATP. Muscle contains in small quantities the oxygen carrying pigment myoglobin (Shephard, 1987). Myoglobin contains an immediate source of oxygen. This small amount of oxygen can delay lactate build up in the muscles. Thus, the greater the store of myoglobin in the muscles, the greater the delay in build-up of lactate. The most important role of myoglobin is to transfer oxygen from the muscle capillaries to the mitochondria (Shephard, 1987). The mitochondria contain many enzymes which can use this oxygen to produce ATP. Therefore, the mitochondria play a role in the provision of energy for muscle contraction. If the nutrient supply is adequate, a muscle which has a large number of mitochondria should be capable of contractions which can be sustained for longer periods of time. A factor which can enhance muscular endurance is the local blood supply in the muscle. A good capillary network is essential for this transport of oxygen and for the removal of waste products.

2. 2. 2. Local Muscular Endurance and Health

There is an association, between low back pain and weakness in certain trunk muscles (Chaffin, 1974 ; Nachemeson, 1982). Nachemeson, (1990) in a review on exercise, fitness and back pain found only a very weak correlation between fitness, in general, and back pain.

2. 2. 3. Development of Local Muscular Endurance

In order to train specifically for muscular strength or endurance, it helps to explain these terms as being at the opposite ends of a continuum. The design of the training programme depends on whether the individual wishes to improve strength, muscular endurance or both. The training load, number of repetitions, number of sets and amount of recovery required has to be taken into consideration. This can be summarised in Figure 1.

GOAL: STRENGTH/POWER	DESIGN VARIABLE	GOAL: MUSCULAR ENDURANCE
90	LOAD (% of 1RM) CONTINUUM	60
1-5	REPETITION(S) CONTINUUM	40+
3-5	SETS CONTINUUM	2-3
3-4	REST TIME BETWEEN SETS (minutes) CONTINUUM	1-2

Figure 1 (Adapted from Baechle, 1984)

To train specifically for local muscular endurance in addition to load, repetitions and sets, the system which supplies the energy necessary for the movement and the amount of force involved has to be examined. For very short bursts of activity (10-15 seconds), the force applied will be great and the muscles will fatigue quickly. For these activities it is necessary to train the CP-ATP system. Astrand and Rodahl (1986) report that a large proportion of the stores of ATP and CP are exhausted within 15 seconds, so an adequate recovery period is essential to replenish these stores. They recommend a 3 minute recovery between exertion. MacDougall, Ward, Sale et al (1977) reports that 5 months of strength training can increase intramuscular stores of CP and ATP by 22% and 18% respectively.

If movements requiring maximal or near maximal effort last between 45-60 seconds (for example in circuit training exercises, such as press-ups), most of the energy supplied comes from glycolysis, therefore this system has to be trained for such activities. A method of training the lactic acid system suggested by Astrand and Rodahl (1986) consists of 1 minute of activity followed by 5 minutes of rest.

As movement duration increases to beyond one minute, the emphasis moves towards the aerobic system for energy supply (Fleck & Kraemer, 1987). Training in this case will influence myoglobin, the mitochondria the muscle capillary networks, and oxidative enzymes.In addition, intramuscular stores of glycogen can be greatly elevated following resistance training (MacDougall et al, 1977).

2. 2. 4. Gender Differences

The differences in muscular strength between men and women are well documented (Wilmore, 1974; Laubach, 1976). It is reported that women possess 63.5% of the total body strength of men (Laubach, 1976). However, there is considerable variation from one body part to the next. Laubach (1976) found that upper body strength of women varies from 35% to 79% of men's and lower body strength measurements vary from 57% to 86% of men's values. These relationships for the average male and female are absolute values, therefore do not take into account body size. The gender differences are diminished when expressed relative to body mass. They are further diminished when expressed relative to lean body mass (Wilmore, 1974). Indeed, leg strength differences disappear when expressed relative to lean body mass (Watson, 1983). Muscular endurance will show similar comparisons between men and women. Training will result in similar changes in women since the composition of muscle is the same in both sexes (Fleck & Kraemer, 1987). Indeed, Wilmore (1974) has shown that women may benefit from resistance training even more than men, probably because their baseline measures are lower.

The difference between men and women can be attributed to differences in body composition (Katch & McArdle, 1986). Typically, the weight of muscle in the body amounts to 36 % and 43 % for women and men respectively (Dyer, 1982; Katch & McArdle, 1986).This difference is partly due to the influence of the hormone testosterone which has an anabolic effect on muscle development. Testosterone is present in much greater concentrations in men (Vander, Sherman & Luciano, 1985). Therefore men typically have a larger muscle cross-sectional area which results in a greater muscle mass. Wilmore (1974) reported that women can increase strength by up to 50% with virtually no change in muscle size. However, muscles of the same size are reported to be of the same strength in men and women (Dyer, 1982).This results in an overlap between the genders.

2. 2. 5. Measurement of Local Muscular Endurance

There are a number of factors which have to be considered when assessing local muscular endurance. Muscular endurance is specific to a muscle group and to the speed of limb movement. Therefore there is no one test which can evaluate total muscular endurance (Hayward, 1984).

There are various field tests which evaluate muscular endurance in different areas of the body. These include sit-up tests, push-up tests and pull-up tests. However, these tests require individuals to lift their own body weight, which places heavier subjects at a disadvantage over lighter subjects (Pollock et al 1978). This may be overcome by using relative endurance tests which are proportional to body weight (Hayward, 1984). Additionally since local muscular endurance tests require maximal or near maximal effort, factors such as subject motivation have to be considered when comparing intra- and inter- individual scores (Hayward, 1984).

The most common method of assessing local muscular endurance is by performing the desired movement over a given period of time. For example, assessing abdominal endurance by measuring the number of sit-ups which can be successfully executed in one minute. This is the method recommended by Pollock et al (1984). It is important to standardise testing procedures for each subject in order to make the test more valid and reliable.

2. 2. 6. Training Studies and Sit-Ups.

Very few studies (Capen, 1950; Massicote, Avon & Corriveau, 1979; Marcenick, Hodgson, Mittleman et al, 1985; Grant, 1989) have used sit-ups as a method of assessing the effectiveness of a training programme on local muscular endurance. Only one of these studies included female subjects [Massicote et al (1979)].

Capen (1950) used a 2 minute sit-up test to assess the changes in abdominal endurance following an 11 week programme of weight training or conditioning (running, gymnastics). The conditioning group showed a large increase in the number of sit-ups performed (29 to 47 in 2 minutes). Marcinik (1985) used three different training programmes to assess various fitness measures. The programmes were aerobic/calisthenic and two intensities of aerobic circuit training. Abdominal endurance was assessed using a 90 second bent knee sit-up test. All three groups increased from baseline values representing a mean increase of 8%. Grant (1989) investigated the effects of a 10 week programme of exercise on previously sedentary men. The programme consisted of 30 minutes of exercise, three times per week and included 5 minutes of muscular endurance work. The subjects improved abdominal endurance significantly after 10 weeks. Massicote et al (1979) found that a programme of conditioning exercise increased abdominal endurance in men and women, although the changes were not significant.

2. 2. 7. Norm Tables for Abdominal Endurance

Population norm tables have been constructed based on a Canadian population (Canada Fitness Survey, 1981).

Norms for men and women have been included for comparison.

Figures based on a trained or an athletic population would show greater values.

Table 2

Norms for Sit-ups by Age Group and Sex (number of sit-ups in 60 seconds)

	20-29		30-39		40-49	
GENDER	**M**	**F**	**M**	**F**	**M**	**F**
excellent	>43	>36	36	>29	>31	>25
above average	37-42	31-35	31-35	24-28	26-30	20-24
below average	29-32	21-24	22-26	15-19	17-21	7-14
poor	<28	<20	<21	<14	< 16	<6

Section 3 Flexibility

2. 3. 1. Flexibility

Flexibility can be defined as the maximum range of movement available at a joint or group of joints (Alter, 1988). However, flexibility is specific to each joint. That is, a large range of movement in the hip joint does not ensure similar flexibility in other joints, such as the shoulder (Corbin & Noble, 1980; Bryant, 1984). Two basic types of flexibility have been defined (de Vries, 1974). Static flexibility refers to a range of movement about a joint where there is no emphasis on speed of movement. Dynamic flexibility, on the other hand is the ability to use a range of movement at normal or rapid speed while performing physical activity (Corbin & Noble, 1980).

Flexibility can be affected by various factors such as the length of the muscles, by the ligaments, by the tendons and by the type of joint (Corbin et al, 1980). Ligaments bind bones together, while allowing a limited range of movement and their length can determine this range. The lengths of muscles can also determine the amount of movement at a joint. For example, the length of the hamstrings can limit knee flexibility. The type of joint can also determine flexibility. For example, the ball and socket joint of the shoulder has a much greater range of movement than the hinge joint of the knee.

Research suggests that when a relaxed muscle is stretched, most of the resistance to stretch is derived from the connective tissue and sheathing surrounding and within the muscle (Sapega, Quaedenfeld, Moyer et al, 1981). Connective tissue is made up of the protein collagen and a polysaccharide matrix. Connective tissue has two properties which affect the type of stretch it can undergo. These properties are viscosity and elasticity. When it is stretched, connective tissue behaves as if it has both viscous and elastic elements. The elastic elements enable recoverable (elastic) deformation and the viscous elements enable permanent deformation. The connective tissues respond best to lower force and higher temperatures. This implies that the most effcetive means of flexibility development is slow stretching of warm tissues.

There are also various neurophysiological factors which affect flexibility. Proprioceptors, a type of sense organ present in muscles and tendons are involved in the coordination of movement. Muscle spindles are sensitive to changes in muscle length and contain sensory endings which can detect the rate of stretch and how much the muscle is stretched. When a muscle is stretched, the spindles are also stretched. This results in a reflex contraction which resists the stretch. This is the "stretch reflex". Golgi Tendon Organs (GTO's) are sensitive to changes in muscle length and tension. They produce an inhibitory response to the stretch reflex. If the stretch lasts for longer than 6 seconds, the GTO's respond and eventually there is a reflex relaxation in the muscle.

2. 3. 2. Development of Flexibility

To develop a particular type of flexibility, a specific type of training has to be chosen. For example, to improve static flexibility, a stretch would be held in the stretch position for a minimum of 6 seconds with a minimum of movement. Static stretching involves the Golgi Tendon Organs and the inverse stretch reflex, which results in inhibition of the antagonist muscles, allowing them to relax and hence increase the movement in those muscles (de Vries, 1962). Dynamic stretching will result in the stretch reflex being evoked if the muscle is stretched in a quick or jerky movement. This causes the antagonist to stretch and then contract. To improve dynamic flexibility, the individual uses bobbing movements and momentum in an attempt to reach the stretch position.

Both methods of flexibility training have been shown to be equally effective, but static stretching is preferred, since there is less of a danger of injury and soreness (Corbin & Noble, 1980; Stamford,1984; Alter, 1988).

Range of movement can also be improved using another technique, Proprioceptor Neuromuscular Facilitation (PNF). PNF makes use of the Golgi Tendon Organs The principle behind PNF is to initially increase tension in the muscle which is to be stretched. This is done by using an isometric contraction . When the muscle is maximally contracted, it is followed by maximal relaxation (Knortz, 1985) and when the muscle is relaxed, the amount of stretch is improved. There are several PNF methods (Alter, 1988), but the two most common methods are the Contract-Relax (CR) and the Contract-Relax-Agonist-Contract (CRAC) techniques (Etnyre & Lee, 1987). The CR method consists of isometrically contracting a lengthened muscle , relaxing it and following this with further passive lengthening of the muscle . CRAC is identical to CR, except that during the final stretching phase, the muscle opposite to the one being stretched is concentically contracted (Etnyre et al, 1987). Lucas & Koslow (1984) compared static, dynamic and PNF methods for developing flexibility. All methods were comparable with regard to flexibility improvement. Similarly, Hardy & Jones (1985) found ballistic stretching as effective as PNF. Other investigators have reported PNF to the best method of improving flexibility (Cornelius, 1983 ; Surburg, 1983 ; Etnyre et al, 1987; 1988). It is, however, difficult to compare different studies. There are many different

PNF methods and static and ballistic methods are difficult to standardise.

2. 3. 3. Gender Differences in Flexibility.

It is generally reported that females are more flexible than males (Pollock et al, 1984 ; Kippers & Parker, 1987) even among older individuals (Shephard Berridge & Montelpare, 1990). This is especially true of the pelvic region (Kippers et al, 1987). The pelvis of an adult woman is wider than the pelvis of an adult man, because it is adapted for possible childbearing purposes. For this reason, a greater range of movement is possible. Pregnancy itself can affect flexibility in the pelvic region (Brewer & Thomson, 1978). It is thought that production of the hormone relaxin may ultimately permit more rotation in the sacro-iliac joint (Alter, 1988). Corbin & Noble (1980) suggest that different physical activity patterns in males and females may account for the apparently superior flexibility of women.

2. 3. 4. Health Aspects of Flexibility

There are a few health benefits which a flexibility programme can promote.

2. 3. 4. (a). Relaxation

Flexibility exercises, if properly executed, can promote perception of relaxation (Cornelius, 1990). However, relaxation can only occur if muscular tension is diminished. If a muscle is tense, it tends to shorten, weaken and decrease range of movement. Slow stretching exercise has been shown to decrease muscle tension. De Vries & Adams (1972) found that stretching is more effective than meditation in decreasing muscle tension.

2. 3. 4. (b). Low Back Pain

Back pain is a serious problem which affects a very large percentage of the population at some time or other (Kraus, 1961). However, there does not appear to be any agreement on the cause of back pain. Nachemeson (1990) found that increasing flexibility had no positive effect on back pain, but suggested that physical activity could be used to promote healing in low back pain. He could not attribute any cause to the back pain of his patients.

Corbin & Noble (1980), on the other hand, state that low back pain can be caused by inadequate trunk flexibility.

Pollock et al (1984) suggest that in a large number of cases of low back pain results from a combination of inflexibility and inadequate strength. However, excess flexibility in the trunk region may cause joint instability, which may also lead to back pain or injury (Pollock et al, 1984).

2. 3. 4. (c). Relief of Muscular Soreness

There is some evidence which suggests that static stretching can be effective in reducing muscular soreness (Cornelius, 1990). Muscular soreness can occur during or immediately after strenuous activity or it can be delayed to 14-36 hours following exercise. de Vries (1966) has shown that static stretching relieves muscle soreness and decreases electrical activity in the muscle. Additionally, regular static stretching in the pelvic region is reported to decrease the severity of dysmennorhoea (Golub & Christialdi, 1957).

2. 3. 4. (d). Injury Prevention During Physical Activity

Stretching exercises designed to increase flexibility have often been used in an attempt to decrease risk of muscle or joint injury during physical activity (Corbin & Noble, 1980; Bryant, 1984; Cornelius, 1990). Corbin & Noble and Bryant suggest that it is advantageous to possess more than the minimum of joint flexibility in some sports in order to avoid muscle strain or sprain. Recently, Hilyer et al (1990) examined the effects of flexibility training on the incidence and severity of injuries in firefighters. Some individuals served as controls. Although the incidence of injury was not significantly different between the groups, injuries sustained in the treatment group resulted in significantly lower time costs (i.e these injuries were less severe). Adequate joint flexibility may reduce the severity of injury if a muscle is accidently overstretched.

2. 3. 5. Measurement of Flexibility

As already mentioned , flexibility is joint specific, therefore different joints will require specific measures. Flexibility can be assessed using various apparatus such as the flexiometer, goniomter, electrogoniometer and by using photography. A simple apparatus developed to assess hip flexion is the Sit and Reach Board (Wells and Dillon, 1952). This method is used to measure flexibility in the hamstrings and lower back muscles. Jackson & Langford (1989) reported that the sit and reach test possesses high validity as a measure of hamstring flexibility and moderate validity as a measure of measure of lower back flexibility.

2. 3. 6. Training and Flexibility

It is difficult to compare studies on the effects of training on flexibility, since many different methods of assessing flexibility are used and different training methods are used.

Lucas et al (1984) used static, dynamic and PNF methods in a 7 week training programme on college women. All three groups significantly increased flexibility as measured on sit and reach apparatus.

Etnyre et al (1988) compared chronic and acute range of movement changes in hip flexion and shoulder extension between men and women after 12 weeks of flexibility training. Two types of PNF (CR and CRAC) and static stretching were used . All techniques resulted in significantly greater range of movement. PNF techniques were more effective for both men and women.

Sady, Wortman & Blanke (1982) found that only PNF improved flexibility in college men after 6 weeks of training. Ballistic and static stretching groups were not significantly different than controls.

In a study in Glasgow by Grant (1989) a 10 week, three times per week fitness programme, which included flexibility exercise, resulted in a significant improvement in sit and reach scores in exercisers compared with controls.

Programmes which do not include a specific flexibility component do not significantly affect flexibility (Wilmore et al, 1978; Marcenik, 1985).

Wilmore et al (1978) used a circuit weight training programme performed 3 times per week for 12 weeks on male subjects. Flexibility as assessed on a sit and reach test did not change significantly.

Similarly, Marcenik et al (1985) found that there was no significant changes in flexibility following a programme of circuit weight training.

2. 3. 7. Norm Tables

Norm tables for Sit and Reach scores based on a Canadian population have been compiled using data from the Canadian Standardised Tests of Fitness (Canada Fitness Survey, 1981). Norms for men and women are given for comparison.

Table 3

Sit and Reach (cm) Norms by Age Groups and Gender *

AGE	20-29		30-39		40-49	
gender	M	F	M	F	M	F
excellent	>40	>41	>38	>41	>35	>38
above average	34-39	37-40	33-37	36-40	29-34	34-37
average	30-33	33-36	28-32	32-35	24-28	30-33
below average	25-29	28-32	23-27	27-31	24-28	30-33
poor	<24	<27	<22	<26	<17	<24

* A score of 30 cm means that the subject can reach his/her toes.

2. 3. 8. Summary

Flexibility is an important component of health-related fitness which can promote relaxation, assist in injury prevention during physical activity, provide relief of muscular soreness and may be an important determinant in the prevention and treatment of low back pain.

Section 4 Body Composition

2. 4. 1. Body Composition

The human body is made up of several components. The main components are muscle, fat, bone and extra-cellular water. Muscle, bone and other components such as blood make up the lean body tissue or fat free mass. Fat weight is composed of essential fat and storage fat. Essential fat is located in the bone marrow, spinal cord, heart, kidney and spleen and storage fat is found subcutaneously and between the tissues and organs.

2. 4. 2. Gender Differences

There are considerable differences in body composition in men and women. These differences are highlighted in the reference man and woman model proposed by Behnke (McArdle & Katch, 1988). When expressed as a percentage of total body weight, reference man has 44.8 % muscle, 15 % total fat (3 % essential and 12 % storage) and 14.9 % bone. Expressed in the same terms, reference woman has 36 % muscle, 27 % fat (12 % essential, 15 % storage) and 12 % bone. This method is useful as a reference which can be used for comparison.It can be seen that the average woman has a lighter skeleton, lower muscle mass and a higher percentage body fat than the average man. The main difference in the fat content is that females have a greater percentage of essential fat and additionally, there is a reserve of sex-specific fat found in breast tissue and in lower body locations. The sex-specific fat is influenced by the oestrogens. The body fat percentage constitutes the largest difference in body composition between the genders. However, if all individuals are considered, there is considerable overlap in percentage body fat between men and women (Durnin & Womersley, 1974). Durnin & Womersley (1974) conducted a study on a Glasgow population and presented averages and ranges by age group and gender (Table 4).

Table 4

Percentage Body fat for Men and Women aged 20 - 49

MALES

AGE	MEAN	RANGE
20 - 29	15	7 - 30
30 - 39	23	13 - 38
40 - 49	25	11 - 37

FEMALES

AGE	MEAN	RANGE
20 - 29	29	10 - 54
30 - 39	33	19 - 53
40 - 49	35	24 - 61

2. 4. 3. Methods of Assessing Body Composition

The only direct methods of assessing human body composition involves the use of cadavers. However, this method was necessary to enable the development of indirect methods which can be used on living subjects.

2. 4. 3. (a). Hydrostatic Weighing

This method is based on Archimedes Principle. That is, when an object is submerged in water there is a counter force, or buoyancy, which helps keep the object afloat. The weight of water displaced is equal to this counter force. The object is said to lose weight in water. The density of the object is the ratio of the weight in air divided by its loss of weight in water. Therefore by weighing an individual in air and water, body density can be obtained. Body fat percentage can be computed from body density using the Siri equation. This equation assumes that fat tissue and fat-free tissue have densities which are constant.

2. 4. 3. (b). Skinfold Fat Measures

Approximately 50 % of total body fat in adults is stored below the skin (Katch & McArdle, 1988). Skinfold thicknesses are the thickness of double folds of skin and their subcutaneous fat. The relative amount of fat tissue can be calculated from the measures taken. Common sites for skinfolds are subscapular, abdominal, suprailiac, tricep, bicep, chest and thigh. The thicknesses are measured using skinfold calipers. Durnin and Womersley (1974) measured skinfold thicknesses and carried out hydrostatic weighing on a large sample of men and women. They emerged with regression equations to estimate body density from skinfold thicknesses and tables to estimate body fat from the sum of four skinfolds (bicep, tricep, subscapular and supra-iliac).

Errors in skinfold measurement can be large due to many factors including varying skin thickness and compressibility at different sites, time taken to make a measurement, instrument error and the tester. Tester reliability can be increased by practise on as many individuals as possible. This should decrease intra-individual variation. Additionally it is necessary to standardise the site of the skinfold.

2. 4. 3. (C). Other Methods of Measuring Body Composition

Other indirect methods include ultrasound, total body potassium, total body water and computed tomography. A limitation of these techniques is the expense and personnel required. For a review of these techniques, see Brodie, 1988.

2. 4. 4. Energy Balance

The energy balance equation states that body weight will remain constant when energy intake equals energy expenditure. If energy intake exceeds energy expenditure weight will be gained (positive energy balance) and if energy expenditure exceeds energy intake, weight loss should result (negative energy balance).

Total energy expenditure in an organism is made up of three components. These are : Resting metabolic rate (RMR) ; Dietary induced thermogenisis (DIT) and energy cost of physical activity. Physical activity in most individuals accounts for only a small fraction of total energy expenditure, so a moderate increase is unlikely to have a significant effect on the energy balance equation. However, exercise training has been shown to influence other components of energy expenditure. Resting metabolic rate is the major determinant of energy expenditure (Ravussen, Burnand, Schutz et al, 1982).

2. 4. 5. Basal Metabolic Rate

Basal metabolic rate is the minimum amount of energy required to allow the body's vital organs to function in a resting state. It is normally assessed by measuring oxygen consumption in a resting state where a subject has fasted for at least 12 hours. Values for resting metabolic rate are affected by body size and weight, age and gender (Katch & McArdle, 1988). BMR for large people tends to be higher than for smaller individuals, it decreases with age and there are gender differences. Ravussen et al (1982) reported values of 4 kJ/min and 6 kJ/min for normal and obese individuals respectively. Women tend to have values which are 5-10% lower than men in all age groups. This is mainly due to differences in body composition and body size.

2. 4. 6. Effects of Acute Exercise on Metabolic Rate

Exercise is known to increase metabolic rate beyond the duration of the activity. However, the duration of this elevation is uncertain. Some studies suggest that oxygen consumption following exercise returns to resting values within one hour of cessation of exercise (Freedman-Akabas, Colt, Kissilef et al, 1985; Brehm & Gutten, 1986) whereas others maintain that metabolic rate is elevated for longer periods after the exercise bout (Bielinski, Schultz & Jequier, 1985; Maehlum, Grandmontagne, Newsholme et al, 1986; Bahr, Inges, Vaage et al, 1987).

Bielinski et al (1985) studied 10 male athletes. Metabolic rate on the control day was measured from 2pm to the following morning . Each subject was given the same meals. The exercise was carried out at 11am on the day after the control day. It consisted of 3 hours of treadmill exercise at approximately 50% of VO2max with an average energy expenditure of 2100 kilocalories. Metabolic rate was measured continuously until the next morning. On the exercise day there was no significant elevation in energy expenditure beyond 4.5 hours of exercise. However, on the morning after the exercise day, metabolic rate was 4.7% higher than on the morning following the control day. Similarly, Maehlum et al (1986) showed that metabolic rate in a group of men and women was higher following cycling exercise (65-90 minutes at 70% VO2max) than following rest. They found that resting metabolic rate was still raised 24 hours after the exercise. Bahr et al (1987) also studied cycling. In this study, metabolic rate was measured 12 and 24 hours after cycling under 4 different experimental conditions : Rest, 20, 40, 80 minutes at 70% VO2max. It was found that metabolic rate was elevated between 5 and 14%, 12 hours after the exercise. There was no significant elevation 24 hours after cycling. The magnitude of the elevation was proportional to the duration of the exercise. These 3 studies suggest that there is an elevation in resting metabolic rate for up to 24 hours after exercise. The duration of the elevation may be related to the intensity and duration of the exercise.

Other findings suggest that there is no significant increase in metabolic rate following acute exercise (Knuttgen, 1970; Freedman-Akabas et al, 1985; Brehm & Gutin, 1986). Knutten (1970) exercised men and women on a bicycle for 15 to 55 minutes. The energy expended during the post-exercise period ranged from 9 kcalories for 15 minutes of exercise to 25 kcalories for 55 minutes of exercise. The duration of the elevation was not reported, but it was unlikely to be longer than one hour, due to the low magnitude of the post-exercise energy expenditure. Brehm & Gutin (1986) investigated recovery energy expenditure following walking or running exercise in runners and non-runners. Subjects either ran or walked 3.2 Km at intensities between 30 and 70 % VO_2 max. Metabolic rate was only raised for less than one hour post exercise.

The conflicting results obtained in these studies may be due to differences in intensity and duration of the exercise.

2. 4. 7. Obesity

Obesity can be defined as an excessive enlargement of the body due to an accumulation of fat (Katch & McArdle). It is caused by a large imbalance in the energy balance equation, where calorie intake greatly exceeds calories expended.

2. 4. 7. (a) Obesity and Diseases

It is documented that obese persons are more prone to certain diseases than those of normal body fat (Pollock et al, 1978, 1984 ; Katch & McArdle 1988) These conditions include hypertension, coronary heart disease, diabetes mellitus, renal disease, abnormal lipid profiles and menstrual abnormalities.

2. 4. 7. (b) Obesity as a Risk Factor for Coronary Heart Disease

Obesity is risk factor in its own right, but can contribute to other more major risk factors, such as hypertension and high blood cholesterol.

2. 4. 8. The Effect of Exercise Training on Energy Balance

In theory by increasing daily activity, the energy balance should become unbalanced and weight loss should occur. However the process is not as simple as this. Increase in physical activity may be associated with increased food intake (Tichenal, 1988).

Blair, Ellsworth, Haskell et al (1981) compared middle-aged runners (between 35 and 59 years) with sedentary controls. Women ran an average of 55 miles and men an average of 65 miles per week. Runners of both sexes were found to consume about 600 kilocalories per day more than the controls. Earlier work by Parizkova & Poupa (1963) compared training periods with non-training periods in female gymnasts. Energy intake increased by 500 kcalories during the training season.

However, Katch, Michael & Jones (1969) investigated daily calorie intake in female swimmers before and after the competitive season.The intensity and duration of the training was different for the groups and the swimmers intake was 15 % higher for the swimmers . However, there was only a small insignificant increase in calorie intake during the competitive season for both groups. Body weight and body composition did not change for either group of subjects over the five month study period.

Cross-sectional studies comparing physically active men and women with sedentary controls were reviewed by Tremblay, Despres & Bouchard (1985). In general, it was found that active men and women do consume more calories than sedentary ones.

2. 4. 9. Effects of Aerobic Training on Body Composition in Non-Obese Subjects.

A large number of studies have investigated the effects of aerobic training on body composition in non-obese individuals (Epstein & Wing, 1980; Farrell et al, 1980; Wynne et al, 1980; Vaccaro & Clinton, 1981 ; Frey et al, 1982; Williams &Morton,1986; Gaesser & Rich, 1987; Tanaka, Nakadomo & Maeda, 1988; Williford et al, 1988; McCord et al, 1989; Grant, 1989). A variety of training modes have been used (for example - running, cycling and aerobic dancing) and men and women have been used.

Farrell et al (1980), Wynne et al (1980), Frey et al (1982), Gaesser & Rich (1984), Williams & Morton (1986) and Tanaka et al (1988) all found that there was a significant decrease in percentage body fat after undergoing a programme of aerobic exercise.

2. 4. 10. Studies on Women

In work by Wynne et al (1980), women oral contraceptive users, age range 18-30, were assigned to either a 10 week programme of exercise (n=13) or a control situation (n=6). The exercise consisted of a bicycle ergometer interval training programme performed 3 times per week at 70 % of maximum heart rate reserve. Body fat percentage was significantly reduced, after 10 weeks, in the exercise group (28.3+/-4.1 to 26.3 +/- 4.3) but not in the control group. Body weight was unchanged in both groups. The same authors (Frey et al, 1982) also obtained similar results on women who did not use oral contraceptives. On this occasion, the two groups consisted of a continuous cycling group and an interval training group. The exercise was carried out 3 times per week for 10 weeks. Body fat determined by underwater weighing for the combined groups was significantly decreased after training (28.48+/- 1.14 to 26.01 to 26.01 +/- 1.22) without a change in body weight.

Several studies on women have used aerobic dance as a training mode (Vaccaro & Clinton, 1981; Williford et al, 1988; Williams & Morton, 1986; McCord et al, 1989).

In the study by McCord et al,(1989), untrained subjects underwent 12 weeks of aerobic dance , 3 times per week at an intensity of 75-85 % of maximum heart rate reserve. Each session lasted for 45 minutes. Percentage body fat was significantly reduced (25.2+/- 6.87 to 21.23 +/- 6.36), but body weight remained unchanged.There was no non- exercising control group in this research. However, Williams & Morton (1986) carried out very a similar exercise programme on sedentary women and compared results with an age matched control group. Body fat decreased and lean body mass increased in the exercise group only.

Vaccaro & Clinton (1981) and Williford et al (1988) found that aerobic exercise training did not significantly change body composition in women. In fact Vaccaro & Clinton found that subjects who underwent 10 weeks of aerobic conditioning 3 times per week for 45 minutes showed a slight increase in body fat. A similar conditioning programme was used in work by Williford et a (1988). There was no significant change in body composition for exercisers (27.0 +/- 7.0 to 26.4 +/- 3.9 %) or controls (25.1 +/7.5 to 24.7 +/- 8.3) .

These studies confirm that aerobic exercise can reduce body fat, but not necessarily body weight in women.

2. 4. 11. Studies in Non-Obese Men

Men who undergo aerobic exercise training appear to benefit in a similar way to women with regard to changes in body fat. Tanaka et al (1988) studied 18 healthy males who exercised approximately 3.4 times per week over a 4 month period. Body weight did not change, but percentage body fat was significantly reduced (14.6 +/-4.2 to 13.5 +/- 3.3). Similarly, Gaesser & Rich (1984) showed that both high and low intensity exercise can significantly decrease body fat, but not body weight in non-obese males. Similarly, Grant (1989) found that subjects who exercised for 30 minutes, 3 times per week over a 10 week period reduced body fat percentage without a change in body weight.

Epstein & Wing (1980) performed a meta-analysis of aerobic exercise and weight. They found that individuals who exercise lose a larger percentage of fat each week than inactive control subjects. It was also found that heavier individuals who exercise , lose more fat than thin persons who exercise. Additionally, the frequency and intensity, and hence energy cost, of the exercise is related to the amount of fat lost per week. Expenditures of greater than 1,000 kilocalories per week are the most effective. However, even lower energy expenditure is better than no exercise at all.

2. 4. 12. Summary

Body composition is an important component of health-related fitness, particularly percentage body fat. Having excess body fat can be a contributory factor in Coronary Heart Disease as well as increasing the risk of other medical problems such as hypertension and diabetes.

Section 5 Blood Pressure

2. 5. 1. Definition

Each time the left ventricle contracts, a surge of blood enters the aorta distending it and creating pressure within it. The stretch and subsequent recoil of the artery wall travels as a wave through the entire arterial system. This can be felt as a pulse in superficial arteries. At rest, the highest pressure generated by the heart in a healthy 20 year old vascular system is usually about 120mm Hg during systole of the left ventricle. As the heart relaxes, the recoil of the aorta and other arteries provides a continuous head of pressure to maintain blood flow. During diastole of the cardiac cycle,the blood pressure in the arterial system decreases to about 70-80 mmHg. The blood pressure that represents the forces exerted by the blood against the artery walls during a cardiac cycle is normally expressed in the form 120/80 mm Hg, representing systolic and diastolic pressures, respectively.

2. 5. 2. Factors Influencing Blood Pressure

In relation to exercise, mean arterial pressure is more important than systolic and diastolic pressures. Mean arterial pressure is the average of the systolic and diastolic pressures during a complete cardiac cycle and is the product of cardiac output and total peripheral resistance (Fox & Mathews, 1981).

Peripheral resistance is caused by friction between the blood and the blood vessel. The amount of friction depends on the viscosity of the blood, and the length and diameter of the blood vessel. Mean arterial blood pressure is directly related to viscosity and vessel length, but inversely related to vessel diameter (Fox & Mathews, 1981). Although systolic pressure increases considerably during acute exercise, the change in diastolic and mean pressure is minimal. This is mainly due to vasodilation in the arterioles supplying the active muscles. In other words, cardiac output increases, but peripheral resistance decreases, thus minimising any increases in diastolic and mean pressures (Fox & Mathews, 1981). Increases in blood viscosity (as found with altitude training) results in an increase in mean arterial pressure. This is due to a greater number of red blood cells (Fox, Bowers & Foss, 1989).

2. 5. 3. Measurement of Blood Pressure

Although blood pressure can be measured directly within the artery the most commonly used method of measurement is an indirect one using a sphygmomanometer. Blood pressure can vary during the day and from day to day, so normally more than one measurement is taken to assess blood pressure. Inaccuracies can occur due to observer error, instrument error, the use of an inappropriate cuff or the wrong positioning of the cuff on the arm .

2. 5. 4. Hypertension

Hypertension is one of the most common medical problems affecting 15-30% of Western populations (Houston,1989). High blood pressure is undetected in most sufferers (Hart,1986). However, it is a major risk factor for more serious diseases, such as coronary heart disease, renal disease and stroke (Roberts, 1987). Kannel, Doyle, Ostfield et al (1984) reported that men with blood pressure of 160/95 mm Hg or higher increase their risk of CHD by threefold. Blood pressures of between 140/90 mm Hg and 160/95 mm Hg were reported to have double the risk. The same trend exists for women, although their CHD prevalence is lower at any blood pressure (Kannel et al, 1984).

2. 5. 5. Causes of Hypertension

The simplest explanation for hypertension would be that in order for blood pressure to increase, cardiac output, peripheral resistance, or both must be increased (Hagberg, 1990). Most studies of hypertension indicate that hypertensive individuals have normal cardiac output with increased peripheral resistance (Hagberg, 1990). Most hypertensive individuals have diastolic pressures between 90 and 104 mm Hg and / or systolic pressures between 140 and

159 mm Hg (Kaplan, 1984). Mild hypertension accounts for the largest percentage of cardiovascular disease that can be attributed to high blood pressure (Stamler, Neaton & Wentworth, 1989). More cases of coronary heart disease result from hypertension, in terms of morbidity and mortality, than do cases of its other sequels , such as renal disease. Drugs may be used in an attempt to control hypertension, but it is not known if pharmacological reduction in blood pressure results in reduction in CHD (Houston, 1989 ; Multiple Risk Factor Intervention Trial, 1982)

2. 5. 6. Activity and its Effects on Hypertension

2. 5. 6.(a). Epidemiological Studies

Exercise has been used on its own and as an adjunct to the pharmacological treatment of hypertension. It has been reported that physically active men and women have lower systolic and diastolic blood pressure than their sedentary counterparts (Sallis, Haskell, Wood et al, 1986 ; Blomqvist, 1983). Several studies have assessed the relationship between physical activity and subsequent risk of developing hypertension (Paffenbarger, Wing, Hyde et al, 1983 ; Blair, Goodyear, Gibbons et al, 1984 ; Darga, Lucas, Spafford et al, 1989). In the study by Paffenbarger and co-workers (1983), almost 15,000 male Harvard alumni who entered college between 1916 and 1959 were studied and followed up either from 1962-1972 or 1966-1972. During this time , 681 men developed hypertension. It was found that those who did not engage in strenuous physical activity had a 35% greater risk of hypertension than those who did. This risk held for all ages and was greatest for overweight subjects. it was concluded that physical activity is associated with a decreased risk of hypertension.

Blair et al (1984) studied the association between baseline cardiovascular fitness and subsequent risk of hypertension. Subjects consisted of 4,820 men and 1,219 women between the ages of 20 and 65 who had no previous history of elevated blood pressure. Cardiovascular fitness was assessed on a treadmill and to be included in the study, subjects had to reach at least 85% of predicted heart rate. Subjects were followed for 1-12 year intervals. During the follow up there were 240 new cases of hypertension. It was found that individuals who had low levels of cardiovascular fitness had a relative risk which was 1.52 times greater than the fitter subjects.Investigators concluded that cardiovascular fitness may decrease the risk of developing hypertension.

Recently , Darga et al (1989) surveyed 1269 physicians who were regular runners (at least 10 miles per week) and were members of a running club. Control subjects consisted of 683 non running doctors. It was found that 93% of the runners and 81% of the controls had normal blood pressure. Additionally, five times as many non- runners were on medication to control blood pressure.

It would appear that adopting an active lifestyle may decrease subsequent risk of developing hypertension.

2. 5. 6.(b). Aerobic Training and Blood Pressure

Various investigators have assessed the effects of aerobic training on resting blood pressure in normotensive and hypertensive individuals (Hagberg et al, 1983;Cade, Mars, Wagemaker et al, 1984; Duncan et al, 1985; Nelson et al, 1986; Gilders, Voner & Dudley, 1989; Grant, 1989).

2. 5. 7. Aerobic Training and Hypertensive Individuals

Several well controlled studies on men (Cade et al, 1984; Duncan et al,1985; Nelson et al, 1985) have reported reductions in blood pressure in mildly hypertensive individuals following exercise training. Cade et al (1984) assessed the effects of a 3 month aerobic conditioning programme in 105 patients with mild diastolic hypertension. Results showed that all but 4 individuals significantly reduced diastolic blood pressure. Additionally, approximately 50% of individuals on medication at the start of the exercise programme were able to stop medication. Duncan et al (1985) and Nelson et al (1985) found that aerobic conditioning significantly reduced systolic and diastolic blood pressure in men with mild hypertension.

Hagberg (1990) recently conducted a meta-analysis on the hypertensive effects of exercise. He reviewed 25 studies. The age range was 15-70 years with sample sizes of between 4 and 66. The length of the exercise programmes ranged from 4 to 52 weeks. Of the 25 studies, only 3 reported separate results for women. The mean systolic and diastolic blood pressures were 150 mm Hg and 92 mm Hg respectively. Average exercise-induced reductions in blood pressure was 10.8 mm Hg for systolic and 8.2 mm Hg for diastolic. Gilder et al (1989) failed to find any significant decrease in resting and 24 hour ambulatory blood pressure following 16 weeks of training in 8 mildly hypertensive subjects. For a review of hypertension and exercise, see Luft (1988).

2. 5. 8. Aerobic Training and Normotensive Individuals

Most controlled studies on the effects of chronic aerobic exercise on blood pressure have used men as subjects (Pollock, Miller, Janeway etal, 1971; Milesis, Pollock, Bah et al, 1976; Kukkonen, Raumara, Voutilainen et al, 1982). Results have suggested that there are only modest, if any, changes in blood pressure following training.

2. 5. 9. Gender Differences

It is reported that younger women (below 50 years) generally have lower blood pressure than men of the same age and fewer women have hypertension (Lew, 1973). However, after 50 years of age blood pressure in women equals or exceeds that in men of a similar age. Because of the lower incidence of hypertension in women , there is much less in the literature on the effects of exercise training on hypertension in women. However, Roman, Camuzzi, Villalon et al (1981) observed that both systolic and diastolic was lowered by 15- 20 mmHg following 3 and 12 months of low intensity and 12 months of high intensity exercise training.The reduction in blood pressure was not related to changes in fitness as the high intensity group increased VO2 max by twice as much as the low intensity group. Kiyonaga, Arawaka, Tanaka et al (1985) found reductions of between 10 and 15 mm Hg for systolic and diastolic blood pressure following a 10-20 week of mild to moderate exercise. However, this study had limitations since there were no control subjects. Krotkiewski, Mandroukas, Sjorstrom et al (1979) studied the effects of exercise training on obese female hypertensives. They reported that the decrease in blood pressure was less in subjects who lost weight than those whose weight did not change.

Hagberg (1990) in his meta-analysis of 25 studies reported that women appeared to show a greater exercise-induced reduction in blood pressure than men (average reduction of 19 mm Hg versus 7 mm Hg for systolic blood pressure and 14 mm Hg versus 5 mm Hg for diastolic blood pressure). However, the smaller numbers of female subjects will result in greater error, so these findings must be viewed with caution.

2. 5. 10. Summary

Hypertension affects 15 - 30 % of people in the western world and is a primary risk factor for coronary heart disease. The risk of developing hypertension tends to be lower in more active individuals and blood pressure can be reduced following endurance training.

Section 6 Blood Lipids

2. 6. 1. Blood Lipids and Lipoproteins

The normal diet supplies a variety of lipids (fats) including cholesterol and triglycerides. Triglycerides are a major constituent of adipose tissue and are therefore the most important lipid energy source. Cholesterol is essential to cell structures and is an essential precursor of steroid hormones. As well as being stored in adipose tissue, lipids are stored in the liver and in the skeletal muscle. These stores of lipids provide a long term energy supply for muscular 2activity. Although carbohydrate is the initial energy source for physical activity, fats are the more important during prolonged work.

Lipids are insoluble in water (blood) and to enable them to be transported around the body, they are combined with a protein molecule. This combination of lipid and protein is known as a lipoprotein. Lipoproteins are classified according to the relative quantities of lipid and protein. The higher the lipid content, the lower the density of the lipoprotein. There are three major categories of lipoprotein-cholesterol complexes. These are high-density lipoprotein (HDL) , low-density lipoprotein (LDL) and very low -density lipoprotein (VLDL). Low-density and very low-density lipoproteins are responsible for the transport of triglycerides from the liver to the adipose tissue and high-density lipoproteins are thought to be involved with the transport of cholesterol back to the liver for catabolism. HDL contains an enzyme which assists in the transfer of free cholesterol back to the liver, where it is released or converted to bile salts.

2. 6. 2. Blood Lipids as Risk Factors in Coronary Heart Disease

Hyperlipidaemia, or high levels of blood fats, is associated with an increased with increased risk of CHD (Castelli, Doyle & Gordon, 1977; Pollock et al, 1978, 1984). However, it is now known that the relationship between cholesterol and CHD is not simple. The levels of the various lipoproteins are now thought to important indicators of CHD risk. The level of LDL is an important indicator of CHD risk , because LDL is associated with the development of the atherosclerotic plaque (Brooks & Fahey, 1986).There is a positive correlation between CHD and elevated LDL levels (Castelli et al, 1977). On the other hand , higher HDL levels are associated with a decreased risk of CHD (Nash, 1989) and the ratio of HDL/cholesterol as well as HDL levels is an important determinant of CHD risk (McCunney, 1987).Indeed, an inverse relationship between CHD and HDL has been observed (Mills & Wilkinson, 1966) and confirmed (Castelli et al, 1977) and low levels of HDL have been shown to be an independent risk factor (Castelli et al, 1977). Castelli and co-workers assessed the HDL levels in almost 7,000 men and women aged 40 an over. Lowest levels were found in individuals who had CHD. Levels were higher in women. Bush, Fried & Barrett-Connor (1988) state that HDL-C is the most important risk factor in women in relation to CHD, whereas Johansson, Bondjers, Fagar et al (1988) emphasise the importance of high triglyceride levels as an independent risk factor of CHD in women. Jacobs, Mebane, Bangdiwala et al (1990) report that HDL-C is inversely related to smoking, body mass index and triglycerides. In addition they report that LDL is unrelated to HDL in men, but are inversely related in women. They conclude that HDL-C is significantly inversely related to all cardiovascular diseases in men and women and to CHD in men.

2. 6. 3. Physical Fitness and Lipid Levels

2. 6. 3.(a) Total Cholesterol

Total cholesterol levels are similar in endurance trained and untrained individuals (Lehtonen & Viikari, 1978; Williams, Wood, Haskell et al, 1982). This is also true in tennis players, male and female taken together (Vodak, Wood, Haskell et al, 1983) and soccer players (Schnabel & Kindermann, 1982) compared with sedentary individuals. Studies which have used women exclusively have again given similar results. Gibbons, Copper, Blair et al (1983) examined associations between physical fitness and coronary risk factors in women aged between 18 and 65 years. Subjects were placed in one of six fitness categories ranging from very poor to superior. There were no significant differences in total cholesterol between the groups. Morgan, Cruise, Glraardin et al (1986) compared lipid profiles in female endurance runners, weight trainers and sedentary controls. All three groups were found to have similar total cholesterol levels. Similarly, Moore, Hartung, Mitchell et al (1983) compared three groups of women. The groups were a long distance running group, a jogging group and an inactive control group. Again, all groups had similar total cholesterol levels. On the other hand, Williams, Krauss, Wood et al (1986) reported lower total cholesestrol levels in male long distance runners when compared to sedentary men. However, only 12 runners were compared to 64 non-runners. The differnces may have been less apparent if a larger group of runners had been tested. It would appear that there is little association between physical fitness and total cholesterol in men and women, although normally women have lower plasma levels.

2. 6. 3. (b) Triglyceride Levels

Serum triglyceride levels are usually lower in endurance trained athletes (Haskell, 1983; Williams et al, 1986) compared with the normal population. Low values have been reported for long distance runners (Martin, Haskell & Wood, 1977), cross-country skiers (Lehtonen et al, 1978) and tennis players (Vodak et al, 1983). Women generally have lower levels of triglycerides than men (Brownell et al, 1982) and endurance trained women are reported to have significantly lower levels than sedentary controls (Moore et al, 1983).

2. 6. 3.(c) Low Density Lipoproteins

Haskell, Taylor & Wood et al (1980) reported no relationship between total plasma LDL and activity levels in men and women. There does not appear to be any definite relationship between physical fitness and LDL levels (Wood & Stephanick, 1990). However, women have lower levels than men (Brownell et al, 1982).

2. 6. 3. (d) High Density Lipoproteins

High density lipoprotein levels are reported to be higher in male and female runners (Morgan et al, 1986 ; Williams et al, 1985) than in sedentary individuals. There appears to be a dose dependent effect. Moore et al (1983) investigated 45 long distance runners (150 Km per week), 45 joggers (20 Km per week) and 47 sedentary controls. The high milage runners had significantly higher HDL-C levels than the joggers. Both running groups had much higher HDL levels than the controls. Similarly Durstine, Pate & Sparling (1987) found that HDL levels were higher for distance runners compared to recreational runners and controls. Adner, William & Castelli (1980) reported that marathon runners had HDL levels which were 20% higher than controls. Hartung et al (1980) found even larger differences. They found that HDL levels in joggers were 34% higher than controls. Marathon runners had levels 13% higher than joggers. Women have higher levels of HDL-C at all ages (Kannel, 1987).

2. 6. 4. Gender Differences in Baseline Lipid and Lipoprotein Levels

Gender differences in baseline lipid and lipoprotein levels have already been highlighted.That is, women in general have lower levels of total cholesterol, triglycerides and low-density lipoproteins with higher levels of high-density lipoproteins than men. However, there are factors which may account for these differences.

2. 6. 5. Effects of the Menstrual Cycle on Serum Lipids

Several studies have focussed on serum lipid and lipoprotein levels throughout the menstrual cycle

(Mattson, Silverstolpe & Samsloe, 1984; Hemer, de Bourges, Ayala et al, 1985; Woods & Graham, 1986).

Hemer et al (1985) and Woods & Graham (1986) reported that cycle phase did not affect total cholesterol and high-density lipoproteins. In contrast, Mattson (1984) suggested that HDL increased during the luteal phase. Triglycerides vary throughout the cycle according to Mattson (1984) and Woods et al (1986), but Hemer et al (1985) found that triglyceride levels do not fluctuate significantly.

Although investigators were not in total agreement, it would appear that lipid and lipoprotein levels can be influenced by circulating gonadal hormones in women.

2. 6. 6. Oral Contraceptive use and Lipids

Triglycerides are reported to be elevated with oral contraceptive use (Wynn, Mills & Doar, 1969). Oestrogen levels in the blood can influence the level of high-density lipoproteins so it is possible that oral contraceptive use could lower HDL levels (Wynne et al, 1980). As reported earlier, low levels of HDL is associated with an increased incidence of CHD. This could be the possible link with the greater prevalence of CHD among oral contraceptive users (Beral, 1976). However, the effects of the oral contraceptive on lipid and lipoprotein levels seems to depend on the chemical formulation of the "pill" (Bradley, Wingard, Pettiti et al, 1978).

2. 6. 7. Effects of Training on Lipid and Lipoprotein Levels

There is no conclusive evidence that physical activity alters blood lipid profiles favourably. This would require strictly controlled testing conditions. Various factors can influence plasma lipid and lipoprotein levels in humans. These include diet, alcohol intake, age and smoking habits (Wood et al, 1990). Conflicting results have been obtained from training studies. Results depend on the type, intensity, duration and frequency of exercise, the programme length, baseline lipid levels, body composition, dietary habits, alcohol and smoking habits and seasonal fluctuations in blood lipids. To make reasonable comparisons between studies, these factors would have to be controlled.

2. 6. 7. (a) Studies on Men

There have been suggestions that exercise training produces favourable changes in lipid and lipoprotein levels in men (Ballantyne, Clark, Dyker et al, 1978; Craig, Brotherhood, Hill et al, 1981; Brownell et al, 1982; Goldberg & Elliot, 1987; Grant, 1989; Hill, Thiel, Heller et al, 1989). Other investigators have found no significant changes in lipid profiles after training (Linder et al, 1983; Gaesser et al, 1984). Moreover, training may affect only one class of lipoprotein (e.g. HDL ,LDL). Brownell et al (1982) studied the effects of a 10 week programme of aerobic exercise. The men showed a significant decrease in total cholesterol and triglycerides, but no significant changes in low density or high density lipoproteins. Men in a study based in the west of Scotland (Ballantyne et al, 1978) demonstrated a different pattern of change following 6 months of 3 times weekly, unsupervised aerobic exercise. Total cholesterol and low density lipoprotein showed small, non-significant increases, triglycerides decreased significantly and high density lipoprotein increased significantly. All subjects were non smokers and were non-obese (Ballantyne et al, 1978). Hill et al (1989) examined the effects of a 10 week exercise programme on total cholesterol and HDL. Male subjects significantly decreased cholesterol, but not HDL. Subjects in a study by Craig et al (1981) jogged 3 times per week (30 minutes) for 12 weeks. Total cholesterol, triglycerides, HDL and LDL were assessed before and after training. The male group showed significant favourable changes in HDL and LDL, but no significant changes in total cholesterol or triglycerides. In a controlled study conducted on previously sedentary men Grant, 1989) total cholesterol, triglycerides and high density lipoprotein were measured before and after a 10 week programme of exercise. Both the exercise and control groups significantly decreased total cholesterol and increased high density lipoproteins, but neither group demonstrated a change in triglycerides. It is clear that in this study (Grant, 1989) the favourable alterations in lipids could not be attributed to the exercise programme. It is reported that lipids show seasonal fluctuations (Buxtorf, Baudet, Martin et al, 1988). Since the initial samples were taken just after Christmas, the levels may have been elevated. This finding emphasises the importance of controlled experiments.

2. 6. 7. (b) Studies on Women

Although less work has focussed on women, contradictory results have been obtained. In addition, groups of men and women placed within the same study condition have shown different results from each other (Ballantyne et al, 1978; Craig et al,1981; Brownell et al, 1982; Hill et al 1989).

Women in the study by Ballantyne et al (1978) significantly reduced LDL and triglycerides, but showed no changes in either cholesterol or HDL following 6 months of exercise.Female exercisers in work by Hill et al (1989) significantly increased HDL, but demonstrated no change in cholesterol after 10 weeks of aerobic exercise at 70 % of maximum heart rate. Similarly, Hardman & Hudson (1991) examined the effect of brisk walking on cholesterol and HDL in previously sedentary middle-aged women. Subjects walked an average of 155 minutes per week for one year and were compared to an age matched control group. Results demonstrated that total cholesterol did not change , but HDL increased significantly following the walking programme. Most of the change in HDL was evident within 3 months of the start of the exercise. There was no change in body fat, so the change in HDL could not be attributed to this. In contrast, 12 weeks of jogging resulted in a significant reduction in total cholesterol and LDL, but not in HDL OR triglycerides (Craig et al, 1981). Total cholesterol, triglycerides, HDL and LDL were assessed before and after 10 weeks of a YMCA exercise programme. Only cholesterol level showed a significant improvement. Neither Lewis, Haskell, Wood et al (1976) or Santiago et al (1989) noted any significant alterations in lipid or lipoprotein profiles following walking programmes (17 weeks and 40 weeks respectively) in women. Similarly, neither Frey et al (1982) or Williford et al (1987) reported any significant differences in lipid profiles following aerobic dance exercise training. Subjects in the study by Frey et al (1982) showed no significant changes in either HDL-C or triglycerides after 10 weeks of bicycle ergometer exercise. Similarly, a 10 week programme of aerobic dance training (Williford et al, 1982) showed no significant changes in triglycerides, total cholesterol , HDL-C, LDL-C or the ratios of cholesterol/HDL-C and LDL-C/HDL-C. As with men, there are no consistent trends for lipid alterations.

2. 6. 8. Gender Differences in the Effects of Training on Lipid and Lipoprotein Levels

The gender differences in lipid alterations with exercise training are highlighted in studies where men and women follow identical training programmes under identical conditions (Ballantyne et al, 1978 ; Brownell et al, 1982; Craig et al, 1981 ; Hill et al, 1989). Although the results are contradictory for men and women taken separately, all show that there are differences in trends of change for men and women. Meta-analyses conducted on men (Tran, Weltman & Glass, 1983) and women (Lokey & Tran, 1989) show the differences in the numbers of studies on men and women and the differences in results of training. Tran (1983) reported a total of 2,086 exercise and 839 control subjects. Men, in general, show significant reductions in total cholesterol, triglycerides and LDL, but no significant increases in HDL. Lokey & Tran (1989) repeated a meta-analysis on women. A total of 379 women trained for an average of 12 weeks, with 81 subjects serving as controls. Women were found to, in general, to reduce total cholesterol and triglycerides. Overall there were no significant changes in either LDL of HDL. The authors of both meta-analyses emphasised that initial levels of lipids, age, length of training programme, body weight and body fat are important when assessing the effects of exercise training on lipid profiles.

When using female subjects, the length of time between tests may be important. That is, many studies do not consider the menstrual cycle (Brownell et al, 1982 ; Frey et al, 1982 ; Williford et al, 1987). These studies used 10 week training programmes and found no changes in lipid profiles. Since lipid and lipoprotein levels, as well as showing seasonal variations, fluctuate during the menstrual cycle. This may account for some of the gender differences.

2. 6. 9. Summary

Although there is no total consensus of findings,physical activity and exercise training can lead to more favourable lipid profiles in men and women.

Section 7 Psychological Effects of Exercise and Physical Activity

2. 7. Exercise and Mental Health

It has been suggested that vigorous exercise can have positive effects on mental health in both clinical and non-clinical populations (Mutrie, 1987, In MacLeod et al; Doyne, Chambless & Beutler,1983 ; Greist. Klein, Eischens et al, 1983; McCann & Holmes, 1984; Klein, Griest, Gurman et al, Martinsen, 1985; Morgan, 1985).

The positive effects reported include increases in confidence, mood and well-being and decreases in anxiety, depression and type-A behaviour (Taylor, Sallis & Needles, 1985).

2. 7. 1. Depression and Anxiety

A large number of people at some time in their lives suffer from depression in response to stressful situations such as work problems, unemployment, financial problems, problems with a partner, bereavement and so on.There are anti-depressant drugs available, but these may be addictive, which would create further problems. Other forms of treatment for depression include electro-convulsive therapy, counselling, relaxation and exercise. Depression is associated with feelings of hopelessness and sadness (Ledwidge,1980).

Anxiety, on the other hand, manifests itself in a different way. Anxiety can exist in an individual who is not depressed, but individuals can show symptoms of both anxiety and depression. Anxiety has a cognitive and a somatic component. The cognitive component may be perceived as feeling of fear (Ledwidge, 1980) and these feelings may cause somatic symptoms such as an increase in sweating response, increased catecholamine release resulting in increases in heart rate, respiration and blood pressure responses.

2. 7. 2. Classification of Anxiety, Depression and Mood

In clinical settings depression can be accurately diagnosed using specialised diagnostic systems. Somatic indications of anxiety can be identified by measurements such as galvanic skin response, blood pressure and catecholamine levels. Another method of assessing these variables is the use of self-report instruments. When these instruments are used, individuals who score above the normal range (assessed from tests on a normal population) may be classified as having a psychological disorder such as depression. Examples of such self-report instruments include the Beck Depression Inventory (BDI), [Beck et al, 1961] , Profile of Mood States (POMS), [McNair et al, 1971 ; Lorr & McNair, 1980] and State Anxiety Questionnaires (Spielberger, 1970). Self-report instruments are often used in non-clinical settings.

2. 7. 3. Exercise and Depression

2. 7. 3. (a) Clinical Populations

Several investigators have used exercise alone and in conjunction with other forms of therapy in the treatment of clinical depression (Klein et al, 1975; Greist et al, 1979; Reuter et al, 1982; Doyne et al, 1983; McCann & Holmes, 1984; Martinsen, 1985; Mutrie, 1986).

Doyne et al (1983) studied 4 women with severe depression using a multiple baseline design with the subjects serving as their own controls. The exercise consisted of 4 bicycle ergometer sessions per week for 6 weeks. Reductions in depression were found to be significantly greater during the exercise period compared with the attention placebo period. Greist et al (1979) randomly assigned 28 mildly depressed patients to running (1 hour, 3 times per week) or to 1 of 2 types of psychotherapy (1 session per week) for 12 weeks. All groups showed significant reductions in depression.

Klein et al (1985) assigned depressed subjects (self report) to running, group therapy or relaxation/ meditation. All groups displayed significant improvement in depression scores. This positive effect was still evident 9 months after treatment.

Martinsen (1985) randomly assigned 49 depressed people to either aerobic exercise or occupational therapy for a period of 9 weeks. Only the aerobic group significantly reduced BDI scores.

McCann & Holmes (1984) randomly assigned 43 depressed women to either aerobic exercise (1 hour, twice per week), relaxation (20 minutes, 4 times per week) or a waiting list. All 3 groups showed reductions in depression after 12 weeks, but the reduction was significantly greater in the aerobic exercise compared with the other 2 groups.

Mutrie (1986) assessed the effectiveness of using exercise to treat depression within the British National Health Service. Depressed subjects (4 men and 20 women) were randomly assigned to one of 3 groups. Group A underwent 8 weeks of aerobic exercise with strength and stretching exercise introduced after 4 weeks ; Group B underwent 8 weeks of strength and stretching exercise with aerobic exercise introduced after 4 weeks ; Group C had no treatment for 4 weeks followed by 8 weeks of aerobic, strength and stretching exercise. Each subject met with a fitness consultant once every 2 weeks. The consultant taught the exercise and conducted fitness assessments. Psychological measures were assessed using the BDI and POMS. Only Group A had lower BDI scores after 4 weeks. The researcher (Mutrie, 1986) suggested that it was more likely that the aerobic exercise itself caused the reduction in depression rather than spontaneous remission or by the peripheral effects of the experimental situation, since the other groups were unchanged. After 8 weeks of exercise, all groups significantly improved depression scores.

Reuter et al (1982) studied 18 depressed people (classified as being moderately to severely depressed on the BDI scale). They were randomly assigned to either running (20 minutes/3 times per week) with counselling or counselling alone. Significant reductions were achieved in the running/counselling group, but not in the counselling alone group.

Results from most of these studies show that exercise can be included as a method of treating depression in clinical populations in addition to and in conjunction with more common methods of treatment.

2. 7. 3.(b) Normal Populations

Since most individuals outside a clinical setting are not classified as being clinically depressed it is difficult to ascertain whether exercise can reduce depression (or depressed moods) in normal individuals. However, several studies have used normal populations (Ledwidge, 1980; Blumenthal, Williams, Needels et al, 1982; Stephens 1988; Ross & Hayes, 1988).

Blumenthal et al (1982) assessed the psychological changes which accompanied aerobic exercise in healthy middle-aged adults. The exercise was reported to decrease depression in these subjects. Moreover, Ledwidge (1980) concluded that aerobic exercise may be an effective strategy for moderating intensity and frequency of depression and anxiety.

Two recent studies have used telephone surveys to assess the relationship between physical activity and mental health in normal populations (Stephens, 1988 ; Ross & Hayes, 1988). Stephens analysed results from 4 population surveys in USA and Canada. Level of physical activity was found to be positively associated with lower levels of depression and anxiety and general feelings of well-being. Ross & Hayes (1988) found that increased participation in sports is associated with feelings of well-being and reduced depression and anxiety.

2. 7. 4. Effects of Exercise on Mood and State Anxiety

Most psychological research on the effects of exercise in normal healthy populations have looked at the effects on mood and state anxiety.

2. 7. 4.(a) Acute Exercise and State Anxiety

State anxiety can be assessed before and after an exercise bout to establish if exercise can cause a reduction. Results from work in this area has shown conflicting results. Morgan (1979) suggests that intensity of exercise dictates whether there is a reduction in state anxiety. He reports that low intensity exercise does not modify state anxiety, but vigorous exercise results in large increments. However, Steptoe & Cox (1988) found that tension and anxiety were increased following high intensity, but not low intensity exercise. They reported that positive mood changes only occurred after low intensity exercise. Steptoe & Bolton (1988) showed that anxiety increases immediately after high intensity exercise, but declines within 15 minutes of cessation of exercise. During the exercise, anxiety decreased in low intensity, but not high intensity exercise.

In the work by Steptoe & Cox and Steptoe & Bolton, all subjects were women, but Morgan used men and women together. It could be possible that men and women react differently to high and low intensity exercise.

Bahrke & Morgan (1978) compared aerobic exercise, meditation and quiet rest on state anxiety in men. All 3 conditions resulted in significant reductions in state anxiety. In later work Raglin & Morgan (1987) compared the effects of moderate exercise and quiet rest on state anxiety and blood pressure in normotensive and hypertensive men.The variables were

assessed before, immediately after and 3 hours after 40 minutes of rest and before and 3 hours after 40 minutes of aerobic exercise. Both conditions resulted in significant reductions in systolic blood pressure, but only the exercise condition maintained a reduction after 3 hours. Diastolic blood pressure was only reduced following exercise. State anxiety was significantly reduced in the exercise condition. There was a non-significant reduction after quiet rest.
In the hypertensive group the decrease in systolic blood pressure was only maintained for 20 minutes and diastolic pressure was not reduced. State anxiety was significantly reduced under both conditions.

Recently, Petruzello, Landers, Hatfield et al (1991) conducted a meta-analysis of 124 studies on the anxiety reducing effects of exercise. They concluded that exercise is associated with reductions in state anxiety (giving similar effects to other methods of anxiety reduction, such as relaxation). They suggested that in order to reduce trait anxiety, the exercise programme length must exceed 10 weeks. Additionally if physiological measures were used to assess anxiety, EMG and EEG were better than cardiovascular measures such as blood pressure and heart rate.

2. 7. 4. (b) Acute Exercise and Mood

A single bout of exercise has been reported to cause

an elevation in mood. Nowlis & Greenberg (1979) studied the effects of a 12.5 mile run in men and women. Exercisers reported increased feelings of pleasantness following the run.
In an attempt to assess if other types of exercise (non-aerobic) results in an acute elevation in mood, Dyer & Crouch (1988) compared running, an aerobics class , weight training and a no-exercise condition. The 23 men and 47 women were assigned to one of the four conditions. POMS were completed before and after the exercise. The running and aerobics groups experienced a significantly greater positive mood change than the weight trainers or the controls. The weight training group experienced a greater effect than the controls. Being part of a group may have resulted in improved mood profiles for the weight-trainers compared with the controls.

Similarly, Berger & Owen (1983) reported that swimmers do " Feel Better". Later, the same investigators (Berger & Owen, 1988) compared different exercise modes and different practise qualities on the stress-reduction effects of exercise. Swimming, body conditioning, yoga and fencing were compared to 2 control groups, who attended lectures. The researchers reported that each type of exercise differed from each other in meeting the mode requirements for stress reduction. These mode requirements were : Aerobic ; Absence of Competition (inter-personal) ; Predictable (self-paced) ; Repetitive, rhythmical. A POMS and a State Anxiety Inventory (STAI) were administerd before and after each class on 3 occasions. Investigators (Berger & Owen, 1988) noted that swimmers had unusually positive initial moods and repoted less tension and confusion after swimming only after the first day. The yoga group were significantly less anxious, tense, depressed, angry, fatigued and confused after class on all 3 occasions. The body conditioning group showed increases in fatigue, but no other mood changes following exercise. The fencers improved in vigour. One control group attended lectures in PE and the other lectures in health science. The health science group, unexpectedly, reported reductions in depression, anger, fatigue and confusion and the PE group reported no mood changes. Only the yoga group reported significant short term reductions in STAI. The researchers (Berger & Owen, 1988) emphasised the need for a stress reduction taxonomy to distinguish different physical activies. They concluded that swimmers had less opportunity for change than the others, so this could explain the results for swimmers, intense exercise (body conditioning) may negate any psychological benefits of exercise. In addition, yoga satisfied all of the mode characteristics except aerobic, implying that for stress reduction to take place, exercise need not necessarily be aerobic if the other parameters (ie.

absence of competition, predictable and repetitive/rhythmical) are met.

Therefore it can be seen that acute exercise can improve mood and give the regular participant a generally more positive feeling of well-being.

2. 7. 4. (c) Regular Activity and Mood

Some investigators have suggested that active individuals have more positive mood profiles than sedentary ones (Berger & Owen, 1983 ; Morgan & Pollock, 1977). Berger & Owen (1983) assessed the mood states of recreational swimmers compared with non-exercising controls. The swimmers displayed more positive moods. Morgan & Pollock (1977) compared POMS scores of athletes with the normal population. The athletes scored more positively overall.

A possible link of fitness and mood was assessed by Wilson, Morley & Bird (1980), who found that marathon runners had more positive mood profiles than joggers or non-exercisers. The joggers had better profiles than the non-exercisers . The training milage may, however, have distinguished between the joggers and the marathon runners. The weekly training mileage was much higher for the marathon runners, so more time was spent on the activity.

2. 7. 4. (d) Effects of Exercise Training on Mood

To establish if training can result in improved mood profiles, self concept and can promote feelings of well-being, these variables must be assessed before and after a training programme.

Moses et al (1989) compared the effects of aerobic programmes of different intensities in a normal, middle-aged population. Subjects (N=109) were assigned to one of four conditions. These were : High-intensity aerobic training ; Moderate-intensity aerobic training ; Attention-Placebo (strength & flexibility) ; Waiting List.The programme consisted of 4 sessions (1 supervised, 3 unsupervised) per week for 10 weeks. A POMS questionnaire and a questionnaire relating to perceived coping ability was given before and after the exercise programme. Following training, only the moderate exercise group showed significant reductions in tension/anxiety. All 3 groups showed increases in physical well-being.

Blumenthal et al (1982) found that 10 weeks of aerobic training in middle-aged men and women resulted in more positive mood profiles when compared to an aged matched sedentary control group. Similarly, subjects undergoing an 8 week training programme of aerobic fitness classes (Simons & Birkimer, 1988) showed significant improvements in mood compared with non-exercising controls.

A profile of mood questionnaire and a global mood state questionnaire was used to compare the psychological effects of a 12 week programme of aerobic exercise using 3 different modes of exercise (Thow, Newton & Nimmo 1988). One group carried out aerobic dance only, a second group carried out a combination of jogging and aerobic dance, while a third group carried out jogging only. The jogging only and the combination groups showed significant positive changes in mood. The aerobic dance group showed no significant changes. The researchers suggested that the groups which included jogging as a training mode saw the exercise as a challenge since it was undertaken in the winter, giving a possible explanation for the positive changes in these two groups. However, this study (Thow et al, 1988) is limited in that there was no non-exercising control group and that the groups were not matched at baseline. The aerobic dance group differed at baseline in mood profile. However, the results still support the suggestion that exercise training can improve mood profile.

However, work by King, Taylor, Haskell et al (1989) middle-aged men and women showed no changes in a number of psychological variables after a 6 month exercise programme. Variables assessed included quality of sleep, tension/anxiety, ability to concentrate, well-being and general mood. Although no changes in mood were reported in this particular study (King et al, 1989) there is more evidence to suggest that exercise can favourably affect mood (Folkins & Sime, 1981; Morgan & Goldston, 1987).

Exercise is also reported to improve self-esteem and promote feelings of well-being (Berger & Owen, 1983; Ross & Hayes, 1988; Stephens, 1988; Plummer & Koh, 1989).
Population surveys [Ross & Hayes (1988), Stephens (1988)] found that individuals engaged in regular activity have improved self-esteem and feelings of well-being. A 10 week training programme resulted in a significant improvement in self-esteem when compared to a non-exercising group. Sonstroem (1984) in a review concluded that exercise is associated with increased self-esteem.

2. 7. 5. Type-A Behaviour

Typically Type-A individuals are high achievers and aim to carry out as many tasks as possible in as short a time span as possible. They are often extremely competitive, aggressive and dislike interruptions to their progress. Type-A's are often work-oriented and are pre-occupied with deadlines (Matthews & Hayes, 1986).

Type-A behaviour is associated with an increased risk of CHD (Review Panel on Coronary-Prone Behaviour and Coronary Heart Disease, 1981; Rosenman, 1975). Rosenman (1975) found that Type-A individuals have twice the risk of CHD than their type-A counterparts.

2. 7. 5. (a) Exercise and Type-A Behaviour

Exercise has been reported to decrease Type-A behaviour (Blumenthal et al, 1980; 1988). In the earlier study, 46 men were either classified as Type-A or Type-B personalities. All subjects underwent a 10 week training programme of aerobic exercise. All subjects showed significant reductions in coronary risk profiles (including blood lipids and blood pressure) and in Type-A score following the exercise programme. However, there was no non-exercising control group to make comparisons.

Later work (Blumenthal, 1988) compared the effects of aerobic and strength exercise on Type-A behaviour. It was found that both forms of exercise showed reductions in Type-A behaviour.

No research which used non exercising controls could be found, but evidence appears to suggest that exercise can modify Type-A behaviour.

2. 7. 6 Gender Differences in the Psychological Effects of exercise

Research has suggested that there are no differences between men and women in the psychological effects of chronic exercise, either in a clinical or normal population (Blumenthal, 1982; Klein et al, 1985 ; Mutrie, 1986). Mutrie (1986) reported that clinically depressed men (n=4) and women (n=20) improved their depression scores following a programme of aerobic exercise. Similarly, Klein et al (1985) randomly assigned 21 men and 53 women to either group therapy, meditation or running. All three treatments significantly reduced depression scores and no gender differences were reported. Using subjects who were not clinically depressed, Blumenthal et al (1982) reported that a group of men (n=5) and women (n=11) significantly reduced levels of trait and state anxiety and reported more positive mood profiles than matched sedentary controls. Again, no gender differences were noted.

The acute psychological response to exercise is reported to be the same for men and women. Morgan (1979) stated that men and women alike require vigorous exercise in order to reduce state anxiety. Morgan (1980) describes an "Iceberg Profile" in athletes following a bout of activity. This profile (as measured by POMS) is characterised by lower than average scores for depression, confusion, anger, anxiety and fatigue and a higher than average score for vigour. Although Morgan's original work was carried out on men, Berger & Owen (1983) have reported an "iceberg profile" for both male and female recreational swimmers.

Mutrie (1987) has produced a review on the psychological effects of exercise in women. She reported that there were much smaller numbers of women involved in studies on normal populations and the opposite in clinical populations. She concluded that although there appears to be no gender differences, differences in the relative numbers of male and female participants may be masking the actual results.

2. 7. 7. Perception of Effort

Perceived exertion is a description or rating of effort during exercise or physical activity. Rating of perceived exertion (RPE) involves the integration of signals from the periphery (working muscles, joints), from central pulmonary and circulatory functions and from the central nervous system (Birk & Birk, 1987). The signals are summed up by the individual into perceived exertion. The individual uses these somatic signals to describe how he/she feels during activity.

The original model for perceived exertion was devised by Borg, who later (1970) developed a category scale (Ratings of Perceived Exertion Scale or RPE Scale) which was based on work on a bicycle ergometer. This scale (see Appendix E) increases linearly with increasing intensity.

Later work (Borg 1982) has shown that RPE is highly correlated with heart rate. In fact, Borg's 6-20 scale was devised to denote heart rate from 60-200 beats per minute, or each RPE number representing 1/10th of the corresponding heart rate value. These values must not be taken too literally. Errors between 10-15 beats per minute are common.

RPE scale can be used in conjunction with training heart rate ranges when prescribing exercise or monitoring intensity. The RPE scale has been found to be highly related to oxygen consumption (Allen & Pandolf, 1977). They found that ratings of 12-15 on the scale show a high relationship to 60-90 % of VO2 max, which is recommended to elicit a training effect (ACSM, 1990).

Intensity of exercise can be monitored using physiological indices such as heart rate and onset of lactate accumulation or by a psychological method such as the RPE Scale. The American College of Sports Medicine (ACSM, 1986) has recommended the use of perceived exertion as an appropriate method of monitoring exercise intensity during graded exercise testing or during endurance training. Pollock, Jackson & Foster (1986) have summarised the recommended training zone for exercise prescription with regard to oxygen uptake, heart rate and RPE (Table 5)

TABLE 5 Recommended Training Zone for Exercise Prescription

Oxygen uptake	50%	85%
Heart Rate	60%	90%
RPE	12	16
	Somewhat Hard	Hard

-Adapted from Pollock et al (1987)

Williams & Eston (1989) have produced a recent review on exercise intensity and perceived exertion from a psychophysical standpoint. They concluded that perceived exertion is a reliable index of the actual metabolic cost of exercise, although 30 % of the relationship between physiological parameters and perceived exertion remains unaccounted for. They (Williams & Eston, 1989) suggest that source of the variance is likely to arise from the interaction of cognitive, perceptual and affective processes operating within the individual involved in the exercise.

Morgan (1981) recommended that specific instructions should be given to individuals on the use of the RPE scale during aerobic exercise. He suggests that individuals should think on perceived exertion as being the total amount of exertion and fatigue, a combination of all feelings of stress, effort and fatigue, not merely one factor such as leg fatigue or breathlessness.

2. 7. 8. Gender Differences in Perception of Effort

Eston & Williams (1988) reported no differences between men and women when subjects themselves used Borg's 6-20 scale to monitor their own work intensity. Eynde & Ostyn (1986) compared treadmill running and bicycle ergometry on RPE in a group of male and a group of female sports students. Sub-maximal intensities expressed relative to VO_2 max ranged between 68-98 % for women and between 77-99% for men. They found that, with one exception, there were no significant differences in RPE at any level of exercise on the treadmill or the bicycle ergometer for both sexes. The exception was that for women, RPE at VO_2 peak was higher during treadmill exercise than bicycle exercise. Also the females also tended to give higher ratings during sub-maximal work on the bicycle ergometer than on the treadmill, although these differences were not significantly significant. Rejeski (1985) suggested that women typed as "feminine" have a tendency to make higher ratings of perceived exertion than those who are typed androgynous or "masculine". Further work in this field will have to be carried out, but research to date suggests that there are no differences between men and women with regard to perception of effort.

2. 7. 9. Negative Psychological Effects of Exercise

In addition to the positive effects of exercise already mentioned, there are some negative aspects. Some individuals may exercise more and more and become dependent on the exercise. They may experience negative feelings similar to drug or alcohol withdrawal (de Coverley Veale, 1988). The concept of " Runners High " has often been reported (Sachs, 1984 ; Wagemaker & Goldstein, 1980). Exercise dependence can become a negative addiction, where the exercise takes precedence over work, family and social life; exercise tolerance increases and exercise continues even during illness or injury. Feelings of guilt are often experienced if the exercise timetable is interrupted. Addictive effects of exercise may be due to a central release of opioid peptides, such as beta-endorphin (Markoff Ryan & Young, 1982; Harber & Sutton, 1984). Receptors for these peptides are located in the hypothalamus. The same receptors bind to morphine. Indeed, endorphins give similar effects to morphine in relation to pain perception. This may be an explanation for the withdrawal symptoms experienced in individuals who are dependent on exercise.

2. 7. 10. Summary

Exercise can provide beneficial changes in mood, reduce depression, anxiety, type-A behaviour and can promote feelings of well-being in normal and clinical populations, male and female. Exercise can, however, have negative aspects in that it can become addictive resulting in dependence in certain individuals.

CHAPTER THREE

METHODOLOGY

3. 1. Subjects, Design, Measurements and equipment

3. 1. 1. Subjects

Fitness sessions conducted by the Department of Physical Education and Sports Science, University of Glasgow are attended by students and staff (academic, technical and other) of the University at the Stevenson Building. Additionally, the evening Kelvin Hall sessions are open to members of the public as well as the University community. It was, therefore, decided that volunteers for this study should be taken from the University community and from members of the public who were able to attend the Kelvin Hall classes. Subjects had to be females aged between 17 and 50 years. Older subjects were required to be pre-menopausal. A control group consisting of volunteers from the same population was included in the study. Control subjects were matched for age and weight with the exercisers. The use of controls helps to assess if the results are influenced by any testing effects or seasonal variations, as both groups both groups would be equally affected by these extraneous factors.

3. 1. 2. Study Design

To allow for great variability in the measures in certain variables (e.g. blood pressure, heart rate, weight) it is necessary to have sufficient numbers for an exercise group and a control group. Previous work (Grant, 1989) using 25 exercisers and 20 controls gave significant results. For this study, 30 exercisers and 30 controls were chosen as group sizes. An advertisement was placed in the Glasgow University Newsletter asking for volunteers to undertake a 12 week exercise training programme. Volunteers were assigned to the exercise group or the control group. Random assignment was not used. All subjects had to be female, aged between 17 and 50 years, who had not regularly engaged in strenuous physical activity or exercise in the previous 3 months, since sedentary subjects show greater physiological responses to training (Pollock, 1973). To ensure that the subjects were sedentary, an initial telephone activity survey (see Appendix K) was given. Any subjects who reported recent strenuous activity on a regular basis were excluded from the study.(Strenuous activity was defined as any activity which caused an increase in respiration and heart rate for periods of 15 minutes or longer;regular was defined as twice per week or more).Exercisers were given information on the study and were asked to complete a consent form (Appendix A). Additionally, all subjects were asked to fill in a smoking questionnaire (Appendix C) and a food frequency questionnaire (Appendix D) [normal food and drink intake] before and after the exercise programme.

The exercise subjects agreed not to take part in other additional strenuous exercise of significant duration during the study period. The control subjects were asked not to change their current activity habits if possible. All subjects were asked to avoid changing their dietary intake during the 12 week period. Subjects were tested before and after the 12 week wxercise programme.

3. 1. 3. Pilot Study

All testing took place at the Department of Physical Education and Sports Science, Human performance Laboratory at the Kelvin Hall. A pilot study was carried out to assess if the proposed test battery (physiological variables) was suitable and reliable. The variables were tested on the same subjects on consecutive days. The results from the pilot study showed that all tests , except the sit and reach , were reliable. The sit and reach test displayed a test effect from one day to the next. However, other studies (Jackson et al, 1986, 1989) using this method of testing flexibility have found it to be a reliable method. The method of administering this test item was modified for the main study (Candian Standardised Test of Fitness , 1986). Details and results of the pilot study are in Appendix G.

3. 1. 4. Equipment

A list of the equipment used in the study is given in Appendix F. All pieces of equipment were calibrated before Test 1 and Test 2. The operation of all required apparatus was examined on each testing day.

3. 1. 5. Order of Testing

All subjects arrived at the Human Performance Laboratory wearing appropriate clothing (shorts or jogging bottoms, a t-shirt and training shoes). Each subject was tested individually. Before testing began, the name and age of the subject was recorded. The order of testing thereafter was :

1. Blood Pressure and Resting Heart Rate
2. Body weight
3. Height
4. Estimated Body Fat
5. Estimated Oxygen Uptake
6. Sit and Reach test
7. Sit-Up Test
8. Profile of Mood State Questionnaire
9. Blood Cholesterol (on a separate day).

The pilot study confirmed that the order of items 1-7 was suitable.

Testing and re-testing were carried out within 2 hours of each other to minimise variations caused by circadian rhythms (Reilly et al, 1984). With the exception of one day (Test 1), temperature ranged between 20 °C and 22 °C. On the other day, there was a heating failure and the temperature did not exceed 11 °C. Subjects due to be tested on this day were given the option of returning on another day for testing.

3. 2. 1. Subject Preparation

It is necessary to minimise or eliminate variation in the condition of subjects in order to maximise reliability of tests. To do this, all subjects were asked to refrain from caffeine and tobacco use for the 3 hour period before testing (ACSM, 1990). All subjects were asked to avoid alcohol for the 24 hour period preceding the tests. In addition, subjects were asked not to engage in any significant strenuous activity on the day of the test. On the test day, each subject was asked to verify that these conditions were met. One subject had to return at the same time on the following day since she had smoked approximately 30 minutes before she arrived for testing.

3. 2. 2. Blood pressure and resting Heart Rate

Blood pressure and resting heart rate measurements were taken using a Copal digital Blood Pressure Meter (see Appendix F). This device uses a microphone placed within the cuff, which can detect a pulse on the arm.

Subjects first relaxed in a seated position for 5 minutes. Three measurements were taken immediately, 2 minutes and 4 minutes after the 5 minute relaxation period. The mean of the 3 readings for blood pressure and resting heart rate was recorded.

The cuff of the blood pressure meter was placed on the subjects' left arm. Firstly the brachial artery was located by palpation. The microphone of the cuff was placed over the artery and the cuff was tightened using the velcro fastening. The subject rested her arm on the table to enable the microphone to be level with the heart. The cuff was inflated by pressing the inflation button on the meter. Subjects were informed, beforehand of any sounds made during the measurement process. The blood pressure and heart rate readings were given by digital display. The cuff was completely deflated before the next measurement was taken.

3. 2. 3. Body Composition

Body weight in kilograms was measured on scales, with the shoes removed. Standing height was measured in centimetres. An estimate of percentage body fat was carried out using the Durnin and Womersley (1974) method. A Holtain skinfold caliper was used to take measurements on 4 sites of the body (biceps, triceps, subscapular and supra-iliac). The study by Durnin and Womersley (1974) was carried out on a Glasgow based population so it was felt that this was a suitable method for estimating percentage body fat for the present study.

3. 2. 3. (a). Body Composition- Method and Equipment

All measurements were taken on the right side of the body using Holtain Calipers (see Appendix F). The measurements from each site were added and applied to the Durnin and Womersley formula to predict percentage body fat.
The skinfolds for measurement were located in the following way :

The biceps skinfold was a vertical fold taken over the belly of the biceps brachii muscle midway between the shoulder and elbow joints with the arm supinated.

The triceps skinfold was a vertical fold on the posterior aspect of the arm midway between the acromion and olecranon processes with the arm held vertically. The distance between these 2 points was measured to standardise the site.

The sub-scapular skinfold was taken at the inferior angle of the scapula with the fold parallel to the axillary border (45 degrees to the vertical). To standardise the site, the fingers touched the bone.

The supra-iliac skinfold was a vertical fold on the mid axillary line at the crest of the ilium.

Once the site was located, the skinfold was pulled from the underlying layer of tissue and firmly grasped by the thumb and forefinger of the left hand. The jaws of the caliper caught the skinfold 1 cm below the thumb and forefinger which continued to hold the fold of skin throughout the measurement. The trigger of the caliper was completely released during measurement to allow the entire force of the jaws on the skinfold. The caliper was calibrated before Test 1 and Test 2 to ensure that the pressure exerted was standardised. Three measurements were taken to the nearest 0.2 cm. The mean of the three was recorded.

3. 2. 4. Aerobic test

Due to limited resources and availability of equipment, it was decided to carry out an indirect method of predicting aerobic power. This test was carried out using a Monark cycle ergometer and heart rate recording equipment (see Appendix F). An Astrand-Rhyming nomogram was used to estimate VO_2 max.

3. 2. 4. (a) Aerobic Test - Method and Equipment

The saddle height was set so that the subject's leg was almost fully extended when the pedal was in the lowest position. The transmitter of the Sporttester heart rate monitor was attached to the subject's chest. The subject sat in the saddle to allow the heart rate to stabilise. The first workload (3 minutes) was set at 25 Watts for all subjects. The first workload allowed a warm up period and allowed the subject to familiarise herself with the equipment. Additionally, the first workload allowed the tester to check if the subject could maintain the correct cadence. Cadence was given by a digital display on the bicycle. Heart rate and individual ratings of perceived exertion (RPE) were monitored.

The next workload was determined from the heart rate and RPE response of the initial 3 minutes and the third and final workload was determined from the heart rate and RPE response of the second workload. All subjects completed all three workloads at both testing periods. Control subjects were re-tested using the same workloads as Test 1, with the exception of 2 individuals. These subjects had their third workload reduced because their heart rates were increased during the second workload when compared to Test 1. Improvements in fitness after the exercise programme would be likely to affect sub-maximal heart rate at the third workload, so this would have to be altered accordingly. In a previous similar study on men (Grant, 1989) the same three workloads were used for the post-exercise tests. However,in this study (Grant,1989) if the heart rate was not sufficiently high to allow an estimation of VO_2 max to be made, a fourth workload was added to the test. In the present study, however, a mood state questionnaire was to be completed immediately after the physiological testing, therefore it was decided to use three workloads on all subjects to standardise total testing time. To allow comparisons, plots of workload against heart rate were made. Since heart rate and workload are linear for heart rates of between 120 and 170 beats per minute (Astrand & Rodahl, 1977), it is possible to interpolate heart rates for given workloads.

Heart rates were taken at 1.00, 2.00, 2.30 and 3.00 minutes during the first two workloads. Heart rates were taken at 1.00, 2.00, 3.00, 4.00, 4.30 and 5.00 minutes of the final workload. An RPE value was given by the subject during the last 30 seconds of each workload.

The steady state heart rate for the first two workloads was determined by calculating the mean heart rates for 2.00, 2.30 and 3.00 minutes. The third workload steady state heart rate was determined by calculating the mean heart rates at 4.00, 4.30 and

5.00 minutes.The steady state heart rate for the final workload was used to predict VO2 max. The estimated VO2 max was calculated using the method of Astrand & Rhyming (1952).

3. 2. 5. Flexibility

Flexibility of the lower back/hamstrings was assessed using sit and reach apparatus (see Appendix F) which was available. This equipment (Wells and Dillon, 1952) consists of a flat cross board which lies perpendicular to the floor. On the top of the cross board, parallel to the floor, is a board with a scale measured in centimetres. The 30 centimetre line lies directly above the feet, so that a subject who is able to touch her toes would acheive a score of 30. The higher the score, the greater the flexibility in the hamstrings/lower back area.

The subject removed her shoes to perform this test. The subject sat with extended legs, with feet placed flat along the cross board of the apparatus. The tester ensured that the subject's legs remained extended. The subject placed her hands together on the top board and then slid them as far forward as possible. This position was held for 3 seconds. Three readings were taken and the higest of the three was recorded.Subjects were allowed to practise the correct technique before scores were recorded.

3. 2. 6. Sit-Ups

Because of the possible links between low back pain and inadequate trunk strength, a sit-up test was used to assess local muscular endurance in the abdominal region. In addition, all of the fitness sessions at the University involve exercises which can enhance local muscular endurance in the abdominal region.

Subjects were tested using a standard sit-up bench (See Appendix F). Using this equipment ensures that each subject performs the sit-ups with bent knees. This is made possible by a "hump" situated on the surface of the bench. Two rollers are situated at the end of the equipment to provide an anchor point for the subjects'feet. The subject placed her feet (with shoes on) under the rollers and lay back on the bench with knees bent. If the subject was particularly short, the tester held the subject's feet.
The subject held on to her ear lobes using her thumb and forefinger. The elbows were stretched in front of the head. The subject was instructed to sit-up by touching her knees with her elbows and returning to the start position. The angle of incline on the bench was set at 00 for all tests. The subject was allowed to practise to ensure the proper technique. The subject was asked to complete as many sit-ups as possible in a one minute period. The total number of sit-ups in one minute was recorded.

3. 2. 7. Plasma Cholesterol and Triglycerides

Because of limited resources, a small sub-sample from the exercise group (n=8) and control group (n=9) were randomly chosen to provide blood for lipid analysis. Fasting samples of blood were analysed for total cholesterol and triglycerides. Blood samples were taken by qualified personnel at the University Student Health Service. Subjects were asked to give a morning fasting sample of blood and were instructed to fast for 12 hours before the sample was drawn. Blood was removed from the ante-cubital vein (except for one subject who had her sample removed from a vein on the back of her hand on both occasions). Blood was taken with the subjects in a seated position. The same subjects gave blood samples before and after the exercise programme. Analysis of blood was carried out at the Biochemistry Department, Western Infirmary, Glasgow.

3. 2. 8. Profile of Mood State Questionnaire

After the physiological tests were done, subjects were asked to complete a Profile of Mood State Questionnaire (Lorr & McNair, 1980). This questionnaire assesses the mood state of an individual on the day of completion and for the preceeding week. It comprises 72 words describing different feelings, for example angry, peaceful, sad and so on. There are four possible scores for each word.

The score corresponds to a phrase :

0 = Much unlike this ; 1 = Slightly unlike this

2 = Slightly like this ; 3 = Much like this

Subjects marked one answer to each word which was closest to how they felt. A bi-polar form of the questionnaire was used (Appendix L). This type of questionnaire combines 2 opposite factors together for scoring.

These are : Composed-Anxious ;Agreeable-Hostile ; Elated-Depressed ; Confident-Unsure ; Energetic-Tired and Clearheaded-Confused. A score for each of the 6 mood factors is obtained by subtracting the sum of all the negative adjectives from the sum of the positive adjectives. To this total, a constant of 18 is added. The raw scored obtained were converted into T scores. A T score of 50 corresponds to a normal population average with a standard deviation of 10.

3. 2. 9. Training

All subjects in the exercise group were given a Department of Physical Education and Sports Science "Fitness Handbook" to provide training advice and information.Four types of class were offered : Tune-up ; Low-key Tune-up (where the exercise consisted of running, jumping, hopping and calisthenic-type movements with music in the background); Popmobility ; Low impact Popmobility (where hopping, twisting and jumping-type movements were carried out in rhythm to music). In previous work, these sessions were reported to provide an adequate training stimulus(Armstrong & Sutherland,1990). They were given a timetable of classes informing them of the venue and time of the Popmobility (or Low-Impact Popmobility) and Tune-Up (or Low-Key Tune-Up) sessions. A 50% and 75% heart rate reserve (HRR) were calculated for each subject using resting heart rates. This provided subjects with a range of training heart rates which was above the minimum threshold for improving VO_2 max. The top intensity was set at 75% since higher intensities are reported to increase the likelihood of injury in novel exercisers (Pollock et al, 1984).

Training consisted of three Popmobility and/or Tune-Up (any combination) sessions performed as part of a group. Sessions were made up of 20 minutes of aerobic activity, 5 minutes of local muscular endurance and 5 minutes of flexibility exercise. For the first 10 weeks of the exercise programme all of the group sessions were taught by staff of the Department of Physical Education and Sports Science. The remaining 2 weeks were in vacation time and consisted of self-instruction tapes. The experimenter was present at most of the sessions during the last 2 weeks to give advice to subjects if necessary. Exercise group subjects were given training diaries to complete each week. The diaries were required to provide information on training heart rates and ratings of perceived exertion scores, as well as the number of exercise sessions attended. Subjects were asked to report all activity including walking. Control subjects were asked to report their physical activity each week.

Training heart rates were counted by monitoring the pulse during the session. The pulse was counted for 15 seconds and multiplied by 4 to give a figure in beats per minute. Sporttester PE 3000 heart rate recorders with a memory were used to monitor heart rate regularly during a whole training session. These were used to check if subjects were accurately measuring heart rates using the pulse count method. All subjects used the heart rate monitors on at least one occasion during the exercise programme. An example of the training diary is given in Appendix E.

3. 2. 10 Tobacco Usage

All subjects completed a smoking questionnaire (Appendix C) at Test 1 and Test 2 which required information about the type (if any) of tobacco product used and the frequency of use.

3. 2. 11 Food Intake

Dietary intake was not assessed using a weighed food intake. However, a food frequency questionnaire (Appendix D) was completed at Test 1 and Test 2 to establish the normal food type and quantity consumed by each subject. The completed questionnaires were coded and scored manually. This method of dietary assessment was developed in the 1960's (Stefanik & Trulson, 1962; Abramsom, Stone & Kosovsky, 1963). Mullen, Krantler, Grivetti et al (1984) assessed the validity of food frequency questionnaires for the determination of food intake. They (Mullen et al, 1984) concluded that a large percentage of individuals can accurately assess dietary intake using this method. In the present study, the questionnaire was used to check for any major differences in food type of quantity. Actual energy intake was not assessed.

CHAPTER FOUR

RESULTS

4.1 Introduction

A description of the subjects in each group is outlined in section 4. 2. 1.
Results for the physiological, lipid and psychological measures for the exercise group at Test 1 and Test 2 are presented in tables 6-8.
Results of the physiological, lipid and psychological measures for the control group at Test 1 and Test 2 are presented in tables 9-11.
Information regarding the exercise programme is presented in Tables 12 & 13 and Figures 2 & 3.

4. 1. 1. Statistical Treatment of Data

All data were hand scored and analysed by Minitab statistical package on an IBM compatable computer in The Department of Physical Education and Sports Science, University of Glasgow.

Two sample t-tests were carried out on each variable at baseline.

Paired t-tests were used to assess if either group (exercise or control) separately had shown an average improvement from Test 1 to Test 2.

Two sample t-tests were used to determine if the exercise group had shown a greater average improvement from Test 1 to Test 2.

Two sample t-tests were carried out on all measures after the 12 week period.

The statistical analysis was carried out to answer the following :

1. Do the two groups differ in any of the variables at baseline ?
2. Does the exercise group show an average improvement from Test 1 to Test 2 ?
3. Does the control group show an average improvement from Test 1 to Test 2 ?
4. Does the exercise group show a greater improvement than the control group ?
5. Do the two groups differ in any of the variables after the 12 weeks ?

4. 2. Subject Characteristics

A total of 22 subjects completed the exercise programme and 16 control subjects were used for comparison. All 22 exercise subjects were assessed on the physiological and psychological variables before and after the exercise programme. A sub-sample of 8 subjects had lipid assessments carried out.

Similarly, all 16 control subjects were assessed on physiological and psychological variables. A sub-sample of 9 subjects had lipid assessments carried out.

4. 2. 1. Description of Subjects

The exercise group (n=22) had a mean age of 36.59 ± 9.32 years (21 - 48 range) and a mean height of 160.38 ± 6.34 cm (149 -172 range). The control group (n=16) had a mean age of 36.37 ± 8.57 years (21 - 50 range) and mean height 162.84 ± 7.38 cm.

4. 3. Results

Results of each variable tested at Test 1 and Test 2 for the exercise and control groups are presented in tables 6 -11. Test 1 and Test 2 results for the exercise group are found in Tables 6 -8 and in tables 9 - 11 for the control group. The mean, standard deviation and range for each variable at Test 1 and Test 2 are included. The results show favourable changes for the exercisers in body composition, resting and sub-maximal heart rates, blood pressure, aerobic power, flexibility, abdominal endurance, blood lipids and all mood factors. To ascertain whether these changes were significant, or not, they were statistically analysed. The results of the statistical analysis are presented in the next section.

4. 3. 1. Results of all variables at Test 1 and Test 2 for the Exercise and Control Groups

TABLE 6 - Mean, Range and Standard Deviation of Physiological Variables for the Exercise Group at Test 1 and Test 2

VARIABLE	T	MEAN	RANGE	S.D.
Body weight (kg)	1 2	64.26 63.48	52.25-82.60 52.45-80.85	9.35 9.08
Sum of Skinfolds(mm)	1 2	60.76 53.21	29.0-107.5 29.3-89.9	20.83 17.05
Estimated % Body Fat	1 2	30.70 29.03	19.0-40.4 19.5-38.2	5.36 5.08
Resting Heart Rate	1 2	73.56 70.50	96-148 57-89	7.89 8.45
SBP (mmHg)	1 2	120.73 118.55	96-148 93-143	12.21 11.06
DBP (mmHg)	1 2	78.76 73.36	59-100 61-90	9.48 8.54
*Steady State Heart rate 1	1 2	108.86 100.86	86-156 83-125	15.3 10.78
Steady State Heart Rate 2	1 2	125.50 116.50	103-161 96-147	15.73 13.12
Steady state Heart Rate 3	1 2	148.32 134.82	127-180 117-156	12.78 12.55
$\dot{V}$O2 max (L/min)	1 2	1.84 2.14	1.27-2.25 1.46-2.70	0.40 0.50
$\dot{V}$O2 max (ml/kg/min)	1 2	28.68 33.75	19.94-38.65 24.15-46.25	5.31 6.40
Sit and Reach (cm)	1 2	34.32 37.91	17-48 24-48	7.31 6.68
Sit Ups (per minute)	1 2	19.29 26.09	10-32 17-43	6.84 7.98

* Steady state heart rates at 1st, 2nd and 3rd workloads on the bicycle ergometer.

T = Test number; SBP = Systolic Blood Pressure
DBP = Diastolic Pressure

TABLE 7 - PLASMA LIPIDS

Mean, range and standard deviation for plasma lipids for the Exercise Group at Test 1 and Test 2

VARIABLE	T	MEAN	RANGE	S.D.
Cholesterol (mmol/L)	1	5.73	4.7-8.6	1.08
	2	5.67	4.4-9.8	1.55
Triglyceride (mmol/L)	1	0.98	0.5-1.5	0.39
	2	0.91	0.6-2.0	0.48

Cholesterol = Total cholesterol in the plasma
Triglycerides = Total triglycerides in the plasma

TABLE 8 - PSYCHOLOGICAL VARIABLES

Mean, range and standard deviation for mood factors for the exercise group at Test 1 and Test 2

MOOD FACTOR	T	MEAN	RANGE	S.D.
Composed-anxious	1	47.19	28-67	9.26
	2	54.68	24-72	12.50
Agreeable-Hostile	1	46.33	38-62	7.10
	2	52.79	39-72	10.31
Elated-Depressed	1	47.24	32-63	9.58
	2	55.79	40-68	8.61
Confident-Unsure	1	47.38	35-64	7.90
	2	54.10	38-64	9.76
Energetic-Tired	1	47.24	37-68	7.94
	2	56.58	41-68	6.95
Clearheaded-Confused	1	50.43	29-68	10.0
	2	56.10	36-72	9.75

T = Test number

TABLE 9

Mean, range and standard deviation for the physiological variables for the Control group at Test 1 and Test 2

VARIABLE	T	MEAN	RANGE	S.D.
Body (kg) Weight	1 2	62.00 61.89	51.00-97.95 51.51-92.95	11.58 10.36
Sum of (mm) Skinfolds	1 2	50.58 48.93	30.4-116.4 30.0-102.0	20.05 17.10
Estimated Body Fat (%)	1 2	28.71 28.41	21.9-41.4 21.8-40.0	5.01 4.66
Resting Heart Rate	1 2	71.94 73.04	60-106 60-89	11.32 9.39
SBP (mm Hg)	1 2	118.62 117.19	104-147 106-138	11.47 8.29
DBP (mm Hg)	1 2	77.50 73.00	91-112 61-84	8.92 8.13
* Steady State HR 1	1 2	104.50 104.06	91-112 89-118	9.27 9.33
Steady State HR 2	1 2	121.44 121.37	107-137 106-138	11.18 11.05
Steady State HR 3	1 2	148.08 144.94	127-170 128-161	9.51 9.42
Estimated $\dot{V}$O2max(L/min	1 2	1.82 1.84	1.36-2.63 1.39 2.63	0.38 0.39
Est $\dot{V}$O2 max (ml/kg/min)	1 2	29.16 30.10	21.58-45.52 20.27-44.50	6.23 6.31
Sit and Reach (cm)	1 2	35.94 35.06	27-54 27-53	7.89 7.20
Sit ups (per minute)	1 2	19.38 21.56	7-44 8-53	10.22 11.32

T= Test Number
STEADY STATE HR = Heart rates at workloads 1, 2, 3 on the bicycle ergometer
SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure

TABLE 10 - PLASMA LIPIDS

Mean, range and standard deviation for blood lipids for the control group at test 1 and Test 2.

VARIABLE	**T**	MEAN	RANGE	S.D
Cholesterol (mmol/L)	1 2	4.99 4.67	3.7-6.1 33.-5.8	0.68 0.73
Triglyceride (mmol/L)	1 2	0.72 0.76	0.5-1.0 0.5-1.4	0.18 0.27

TABLE 11 - PSYCHOLOGICAL FACTORS

Mean, range and standard deviation for mood factors (T Scores) for the control group at Test 1 and Test 2

MOOD FACTOR	**T**	MEAN	RANGE	S.D.
Composed-Anxious	1 2	50.13 53.93	29-69 33-73	12.76 13.72
Agreeable-Hostile	1 2	47.93 52.60	38-72 37-72	12.76 11.72
Elated-Depressed	1 2	47.60 46.53	31-68 30-68	11.48 12.38
Confident-Unsure	1 2	47.33 49.40	36-63 31-67	9.66 12.03
Energetic-Tired	1 2	46.20 45.73	31-63 35-66	9.85 9.33
Clearheaded-Confused	1 2	50.60 52.80	38-61 29-61	7.74 9.16

T = Test Number

Figure 3 represents the POMS Scores for the control group at test 1 and Test 2

4. 3. 3. The Exercise Programme

(a) Adherence

To be included for analysis, subjects had to complete a minimum of 24 sessions. This number was chosen, since it would represent a mean frequency of 2 sessions per week. This frequency is the minimum recommended by ACSM (ACSM, 1990).

22 subjects completed the exercise programme. One subject moved away from the area and three other subjects had to drop out due to injury or illness. The other four subjects opted out of the study, since they felt that the exercise programme was too much of a time commitment.These subjects failed to complete a minimum of 24 Popmobility or Tune-Up sessions.

The 22 exercise subjects attended a mean of 29.9 ± 4.32 sessions over the 12 week period. Attendance ranged from 24- 41 sessions, although only 2 subjects attended more than the 36 required sessions. All control subjects completed Test 1 and Test 2

(b) Training Diary Information

Heart rates values and ratings of perceived exertion scores for each exercise session were recorded in subjects' training diaries which were collected weekly. Heart rate was measured and RPE was assessed 20 minutes into the exercise session. From this information, mean training heart rate, intensity and RPE values were calculated. The weekly mean heart rates, intensity and RPE scores are presented in Table 12.

Mean training heart rates remained fairly constant throughout the 12 week period (see Figure 2). Mean ratings of perceived exertion scores changed from "Hard" as reported for the first 3 to 4 weeks to "somewhat hard" by the final 5 weeks of the exercise programme (see Figure 3).

TABLE 12 Mean training heart rates, mean intensity* and Ratings of Perceived Exertion (RPE) for the exercise

Week Number	Mean Heart Rate	Mean (%) Intensity	R.P.E.
1	147.05	79.92	15.10
2	146.75	79.75	14.70
3	147.14	79.97	14.62
4	151.80	82.50	14.05
5	153.05	83.18	13.75
6	150.79	81.95	14.00
7	150.47	81.78	13.53
8	154.13	83.77	13.00
9	152.67	82.97	12.75
10	146.00	79.35	13.08
11	149.33	81.16	12.31
12	147.93	80.30	12.64

* Based on percentage of age-predicted maximum heart rate

Figure 2 - Mean Training Heart Rates throughout the Exercise Programme

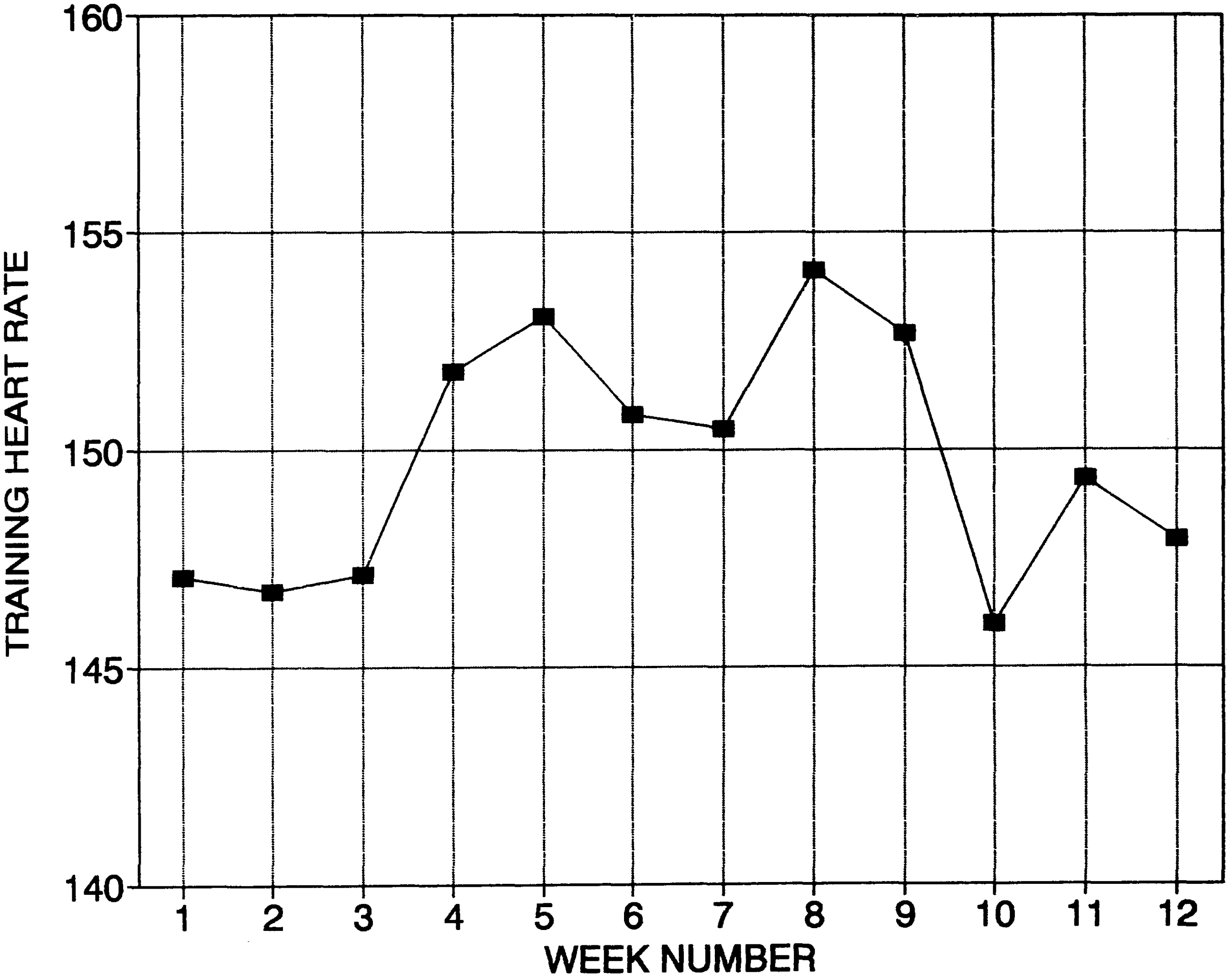
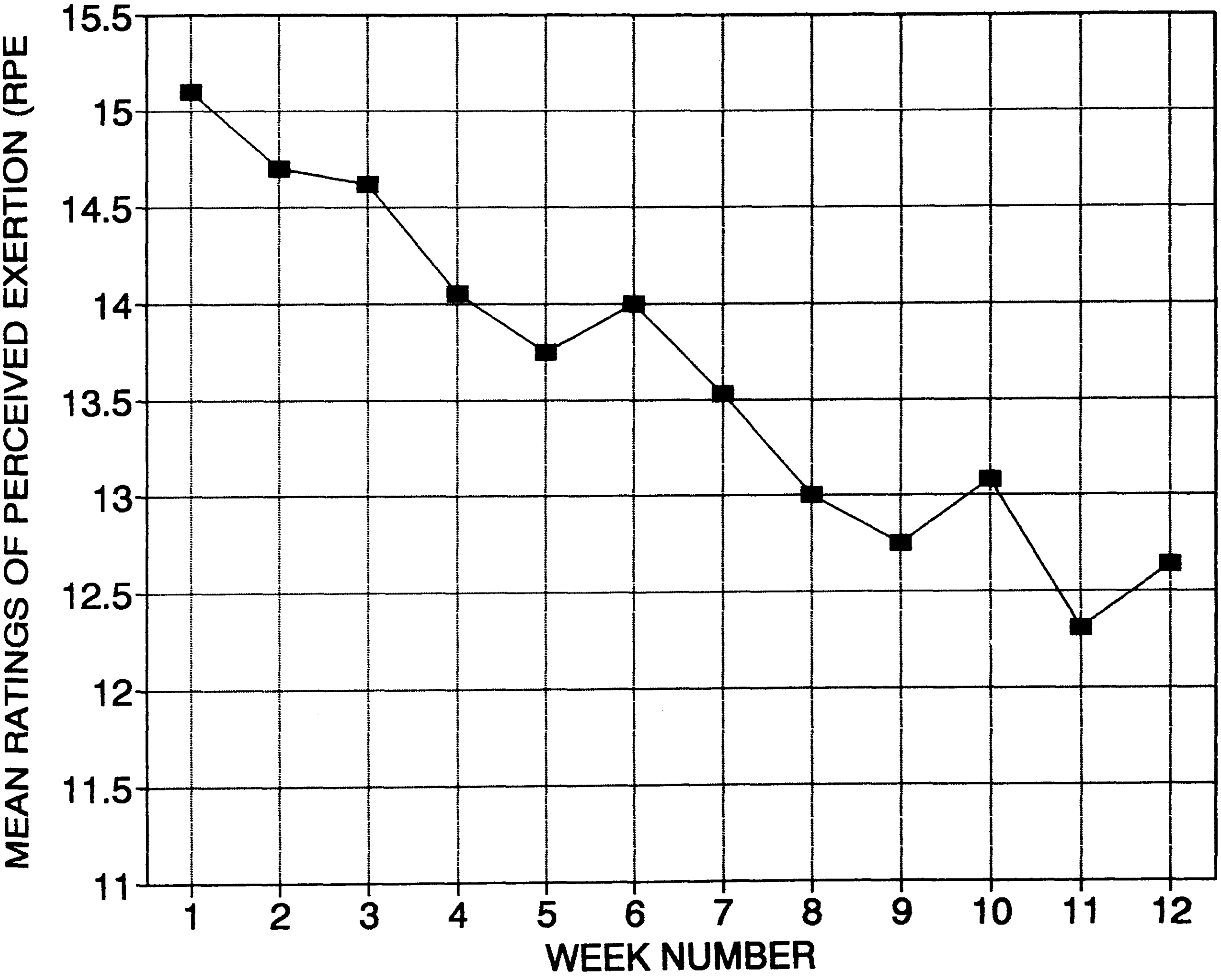


Figure 3 - Mean RPE throughout the Exercise Pr ogramme



4. 4. Statistical Analysis of Results

4. 4. 1. Analysis of Baseline Measures

The exercise group and control group were compared on each variable at Test 1. Two sample t-tests and 95 % confidence intervals were carried out on the baseline data. A 5 % level of significance was chosen.

Results of the t-tests revealed that the groups did not differ significantly on any of the variables measured. The results of these t-tests are presented in Appendix H.

4. 4. 2. Analysis of Changes over the 12 week period.

(a) Treatment of Data

Paired t-tests were used to assess if either group (exercise or control) separately had shown an average improvement in any of the variables from Test 1 to Test 2.

Two sample t-tests were used to determine if the exercise group had shown a greater average improvement than the control group.*

95% confidence intervals were used to show the range of average improvement.

(b) Results of statistical analysis

Results of analysis are presented in tables 13 - 29

* See page 140

4. 4. 3. Analysis of Test 2 Results

Two sample t-tests were carried out on results of each variable at Test 2. These analyses revealed that the groups were significantly different ($p < 0.05$) in only three measures after the 12 week period. These measures were predicted $\dot{V}O_2$ max (Litres/minute) and POMS scores for elation-depression and energy-tiredness. The exercise group had significantly greater scores than the control group for these variables after the 12 weeks.

Results of the t-tests are presented in Appendix J.

* Distributions for all 19 variables were tested and the following variables were found to be non-normal : $\dot{V}O_2$ max (L/min) ; Elated-Depressed T score ; Confident-Unsure T score ; Energetic-Tired T score. Mann-Whitney tests were carried on these variables. These tests gave the same results for statistical significance or not as two sample t-tests, but the p values were somewhat lower.

TABLE 13 BODY WEIGHT

TABLE 13 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.79	-2.22	0.037	(-1.52, -0.05)
Control	-0.12	1.66	0.25	(-1.09, 0.86)

TABLE 13 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.79	-1.16	0.25	(-1.85, 0.51)
Control	-0.12			

The exercise group demonstrated a small,but significant average reduction (0.79 Kg, P <0.005) as shown by a paired t-test. The decrease demonstrated by the control group did not reach significance.

A two-sample t-test and confidence interval revealed that the average improvement shown by the exercise group was not significantly greater than the control group.

TABLE 14 SUM OF SKINFOLDS

TABLE 14 A Paired t-test and 95% Confidence Intervals (C.I.)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-7.54	-5.67	0.001	(-10.31,-4.78)
Control	-1.65	-1.66	0.12	(-3.77, 0.47)

TABLE 14 B
Two sample t-test of Differences and 95% Confidence Interval of Average Improvement (Exercisers over Controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-7.54	-3.33	0.001	(-9.3, -2.52)
Control	-1.65			

The Exercise group demonstrated a significant average decrease (7.54 mm, p < 0.001) in sum of skinfolds from Test 1 to Test 2 as shown by the paired t-test. The control group showed a small non-significant decrease.

A two sample t-test and confidence interval demonstrated that the exercise group showed a significantly greater (p< 0.001) average decrease in sum of skinfolds than the control group from Test 1 to Test 2.

TABLE 15 ESTIMATED PERCENTAGE BODY FAT

TABLE 15 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-1.67	-8.96	0.001	(-1.17,-2.17)
Control	-0.30	-1.94	0.071	(-0.63, 0.03)

TABLE 15 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-1.67	-6.90	0.001	(-1.39,- 2.55)
Control	-0.30			

The exercise group demonstrated a significant average decrease (1.67 %, p < 0.001) in percentage body fat fron Test 1 to Test 2 as shown by the paired t-test and confidence intervals. The control group showed a small, non-significant decrease.

A two sample t-test and confidence intervals demonstrated that the improvement in percentage body fat shown by the exercisers from Test 1 to Test 2 was significantly greater than that shown by the controls.

TABLE 16 RESTING HEART RATE (BEATS PER MINUTE)

TABLE 16 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-3.05	-2.06	0.052	(-6.12, 0.03)
Control	-0.12	1.66	-0.25	(-3.81, 6.06)

TABLE 16 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-3.05	-1.52	0.14	(-9.8, 1.5)
Control	1.13			

The exercise group demonstrated an average decrease (6.92, $p < 0.06$) in resting heart rate from Test 1 to Test 2 which was of borderline significance as shown by a paired t-test and confidence intervals.

A two sample t-test showed that the exercise group did not demonstrate a significantly greater improvement than the controls in resting heart rate.

TABLE 17 SYSTOLIC BLOOD PRESSURE (mm Hg)

TABLE 17 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-2.18	-2.11	0.047	(-4.34, -0.03)
Control	-1.44	-0.68	0.50	(-5.92, 3.04)

TABLE 17 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-2.18	-0.32	0.75	(-5.6, 4.1)
Control	-1.44			

The exercise group demonstrated a small, but significant decrease (2.18 mm Hg, $p < 0.05$) and the control group a small, non-significant decrease in systolic blood pressure from Test 1 to Test 2 as shown by a paired t-test and confidence intervals.

A two sample t-test and confidence interval revealed that the exercise group did not show a greater average improvement than the control group.

TABLE 18 DIASTOLIC BLOOD PRESSURE (mm Hg)

TABLE 18 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-5.50	-3.89	0.001	(-8.44, -2.56)
Control	-4.50	2.65	0.018	(-8.11, -0.89)

TABLE 18 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-5.50	-0.45	0.65	(-5.5, 3.5)
Control	-4.50			

Both the exercise group and control groups demonstrated significant average decreases in diastolic blood pressure from Test 1 to Test 2 as shown by paired t-tests and confidence intervals.

A two sample t-test revealed no greater average improvement for the exercise group compared with the control group.

TABLE 19 STEADY STATE HEART RATE AT 25 WATTS (BEATS PER MINUTE)

TABLE 19 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-8.0	-4.28	0.001	(-4.11,-11.89)
Control	-0.44	0.24	0.82	(-3.48, 4.36)

TABLE 19 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-8.0	-2.88	0.007	(-12.9, 2.2)
Control	-0.44			

Paired t-tests and 95% confidence intervals revealed that the exercise group significantly reduced steady state heart rate for the first workload from Test 1 to Test 2.

A two sample t-test and confidence interval demonstrated that the exercise group showed a significantly greater decrease than the controls.

TABLE 20 STEADY STATE HEART RATE AT 50 WATTS (BEATS PER MINUTE)

TABLE 20 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-9.0	-4.33	0.001	(-4.67,-13.33)
Control	-0.06	0.03	0.98	(-4.24, 4.36)

TABLE 20 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-9.0	-3.08	0.004	(-14.8, -3.1)
Control	-0.06			

Paired t-tests and 95% confidence intervals revealed that the exercise group significantly reduced (9 beats per minute, $p < 0.001$) steady state heart rate on the second workload from Test 1 to Test 2.

A two sample t-test and confidence interval showed that the exercise group had shown a significantly greater reduction ($p < 0.01$) than the control group.

TABLE 21 STEADY STATE HEART RATE AT 75 WATTS (BEATS PER MINUTE)

TABLE 21 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-13.5	-6.65	0.001	(-9.28,-17.72)
Control	-3.12	-2.09	0.054	(0.06, -6.31)

TABLE 21 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-13.5	-4.12	0.001	(-15.5, -5.3)
Control	-3.12			

Paired t-tests and 95% confidence intervals revealed that the exercise group significantly reduced (13.5 beats per minute, $p < 0.001$) steady state heart rate at 75 Watts. The control group also showed a reduction (3.12 beats per minute, $p < 0.06$) which was of borderline significance.

However, a two sample t-test and confidence interval demonstrated that the improvement shown by the exercise group was significantly greater ($p < 0.001$) that that shown by the control group.

TABLE 22 ESTIMATED VO_2 MAX (LITRES/MINUTE)

TABLE 22 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	0.30	6.77	0.001	(0.21, 0.40)
Control	0.02	0.57	0.58	(-0.07, 0.12)

TABLE 22 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	0.30	4.44	0.001	(0.15, 0.41)
Control	0.02			

The exercise group demonstrated a significant average increase (0.30 L/min, $p < 0.001$) in VO2 max from Test 1 to Test 2 as shown by a paired t-test and confidence interval.

A two sample t-test and confidence interval revealed a much greater average improvement for the exercise group than the control group.

TABLE 23 ESTIMATED VO$_2$ MAX CORRECTED FOR WEIGHT (ml/kg/min)

TABLE 23 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	5.07	7.45	0.001	(3.65, 6.49)
Control	0.95	1.30	0.21	(-0.61, 2.50)

TABLE 23 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	5.07	4.14	0.001	(2.10, 6.16)
Control	0.95			

The exercise group demonstrated a significant average increase (5.09 ml/kg/min, $p < 0.001$) in weight corrected VO2 max from Test 1 to Test 2 as shown by a paired t-test and confidence interval. The control group showed no average change. A two sample t-test and confidence interval revealed a greater average improvement for the exercise group than the control group ($p < 0.001$).

TABLE 24 FLEXIBILITY - SIT AND REACH TEST (cm)

TABLE 24 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	3.59	6.64	0.001	(2.46, 4.72)
Control	-0.87	-1.50	0.15	(-2.12, 0.37)

TABLE 24 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	3.59	5.61	0.001	(2.85, 6.09)
Control	-0.87			

The exercise group demonstrated a significant average increase (3.59 cm, $p < 0.001$) in sit and reach score from Test 1 to Test 2 as shown by a paired t-test and confidence interval. The control group showed no average change.

A two sample t-test and confidence interval revealed that the improvement shown by the exercise group was much greater than that shown by the control group ($p < 0.001$).

TABLE 25 ABDOMINAL ENDURANCE - SIT UP TEST (REPETITIONS PER MINUTE)

TABLE 25 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	6.82	3.85	0.001	(5.11, 8.53)
Control	2.19	2.48	0.003	(0.85, 3.51)

TABLE 25 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	6.82	4.50	0.001	(2.54, 6.72)
Control	2.19			

Both the exercise group and the control group demonstrated an average increase in the number of sit ups performed in one minute from Test 1 to Test 2 as shown by paired t-tests and confidence intervals.

A two sample t-test , however, revealed that the exercise group showed a greater average improvement than the control group.

TABLE 26 TOTAL CHOLESTEROL (mmol/Litre)

TABLE 26 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.07	-0.35	0.73	(-0.52, 0.38)
Control	-0.32	-1.48	0.17	(-0.81, 0.17)

TABLE 26 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.07	-0.85	0.41	(-0.54, 0.21)
Control	-0.32			

Neither the exercise group, nor the control group demonstrated significant changes ($p > 0.05$) in total cholesterol levels from Test 1 to Test 2 as shown by paired t-tests and confidence intervals.

TABLE 27 PLASMA TRIGLYCERIDES (mmol/Litre)

TABLE 27 A Paired t-test and 95% Confidence Interval

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.13	-0.87	0.42	(-0.49, 0.23)
Control	-0.03	-0.44	0.67	(-0.14, 0.21)

TABLE 27 B

Two Sample t-test of Differences and 95% Confidence intervals of average improvement (exercisers over controls)

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	-0.13	-0.97	0.36	(-0.54, 0.21)
Control	-0.03			

Neither the exercise group nor the control group demonstrated significant changes ($p > 0.05$) in plasma triglycerides from Test 1 to Test 2 as shown by paired t-tests and confidence intervals.

PROFILE OF MOOD STATES (POMS)

TABLE 28 Paired t-tests and 95% Confidence Intervals

TABLE 28 A COMPOSED - ANXIOUS

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	7.11	3.11	0.006	(2.28,11.94)
Control	3.80	2.00	0.065	(-0.27,7.97)

The exercise group showed a significant average improvement (7.11, $p < 0.01$) in composed- anxious score from Test 1 to Test 2 .

TABLE 28 B AGREEABLE - HOSTILE

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	6.11	2.73	0.014	(1.38,10.84)
Control	4.67	1.06	0.31	(-4.74,14.08)

The exercise group showed a significant average improvement (6.11, $p < 0.05$) in agreeable-hostile score from Test 1 to Test 2.

TABLE 28 C ELATED - DEPRESSED

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	8.11	3.35	0.004	(3.00,13.22)
Control	-1.07	-0.41	0.69	(-6.62, 4.49)

The exercise group showed a significant average improvement (8.11, $p < 0.01$) in elated-depressed score from Test 1 to Test 2.

TABLE 28 D CONFIDENT - UNSURE

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	5.44	3.27	0.005	(1.92,8.97)
Control	2.07	1.71	0.76	(-3.74, 7.87)

The exercise group showed a significant average improvement (5.44, $p < 0.01$) in confident-unsure score from Test 1 to Test 2.

TABLE 28 E ENERGETIC - TIRED

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	7.72	5.03	0.001	(4.48,10.96)
Control	-0.47	-0.17	0.87	(-6.44,5.51)

The exercise group showed a significant average improvement (7.72, $p < 0.001$) in energetic-tired factor from Test 1 to Test 2.

TABLE 28 F CLEARHEADED - CONFUSED

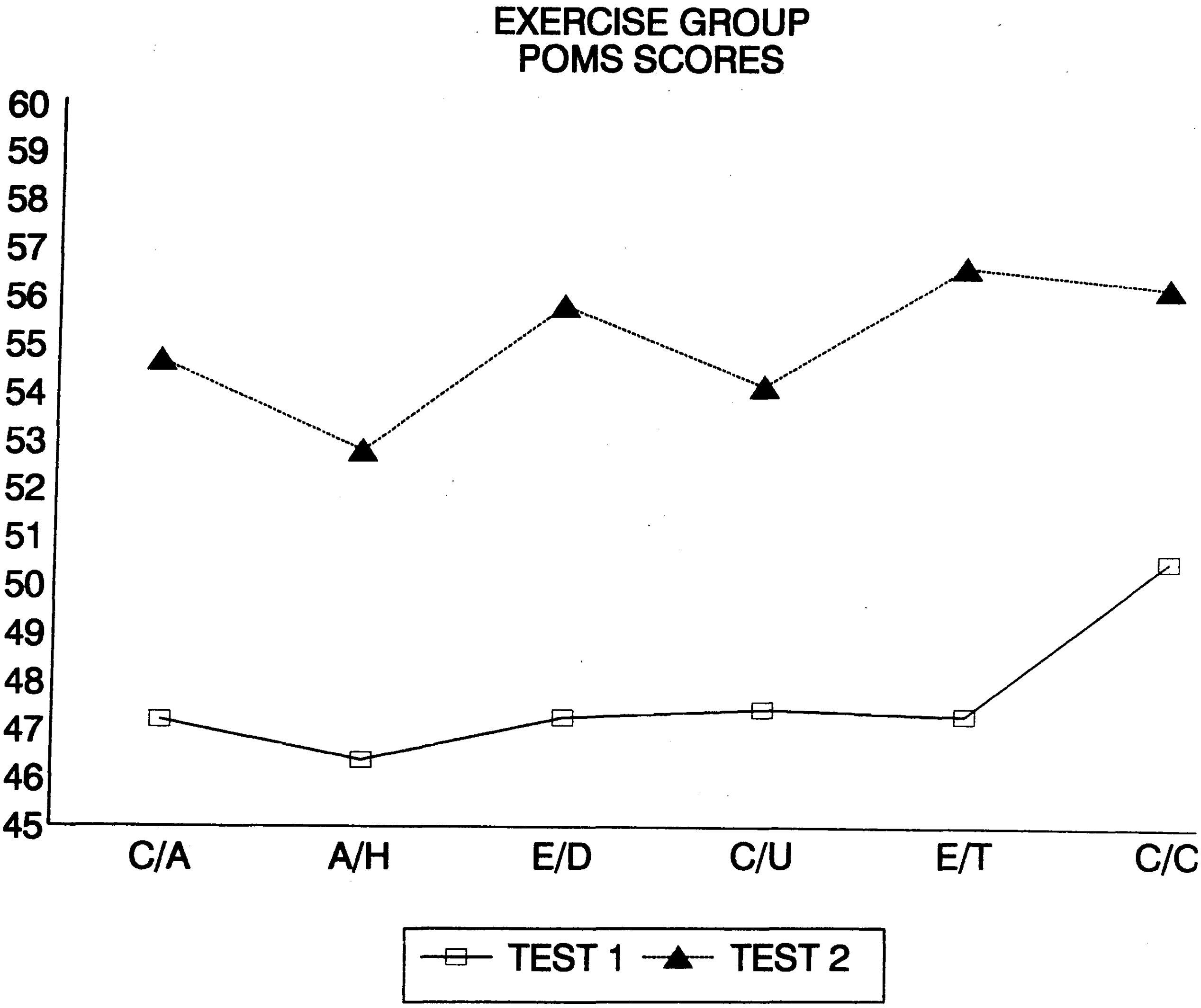
Group	Mean Diff.	t	P Value	95% C.I.
Exercise	4.72	1.73	0.10	(-1.13,10.47)
Control	2.20	2.00	0.065	(-1.87, 6.27)

Neither group demonstrated significant changes in clearheaded-confused scores from Test 1 to Test 2.

The paired t-tests and confidence intervals demonstrated that the exercise group significantly improved all mood factors except the clearheaded-confused factor. The control group showed no significant improvements in any of the mood factors.

Figures 4 & 5 illustrate the changes in mean T scores.

Figure 4 - Mean T Scores for the Exercise Group at Test 1 and Test 2

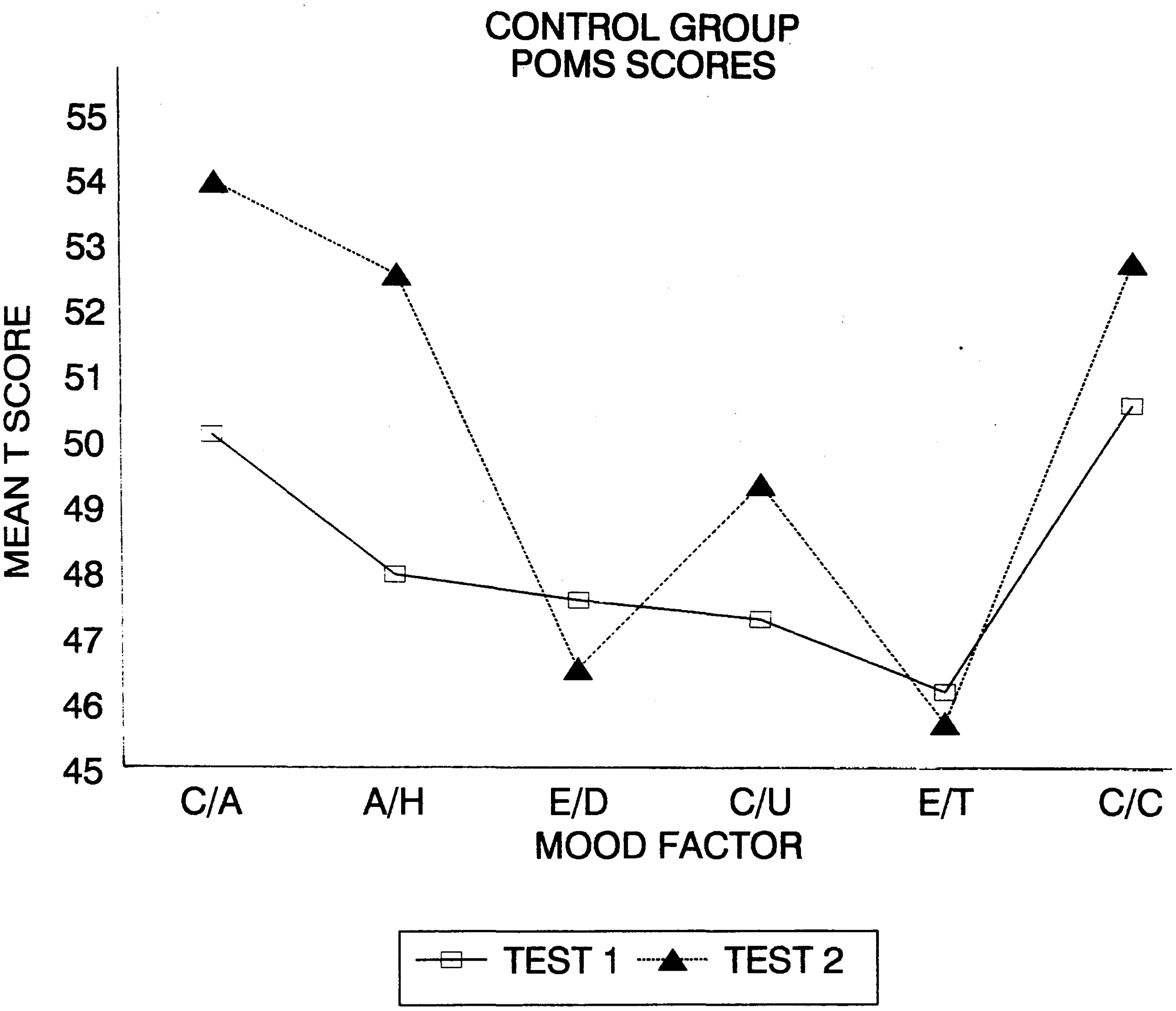


C/A = COMPOSED-ANXIOUS ; A/H = AGREEABLE - HOSTILE

E/D = ELATED - DEPRESSED ; C/U = CONFIDENT - UNSURE

E/T = ENERGETIC - TIRED ; C/C = CLEARHEADED - CONFUSED

Figure 5 - Mean T Scores for the Control Group at Test 1 and Test 2



C/A = COMPOSED-ANXIOUS ; A/H = AGREEABLE - HOSTILE

E/D = ELATED - DEPRESSED ; C/U = CONFIDENT - UNSURE

E/T = ENERGETIC - TIRED ; C/C = CLEARHEADED - CONFUSED

PROFILE OF MOOD STATES (POMS)

TABLE 29 Two sample t-tests of Differences and 95% Confidence Intervals of average improvement (Exercisers over Controls)

TABLE 29 A COMPOSED - ANXIOUS

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	7.11	1.11	0.27	(-2.8, 9.4)
Control	3.80			

TABLE 29 B AGREEABLE - HOSTILE

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	6.11	0.29	0.77	(-8.8, 11.7)
Control	4.67			

TABLE 29 C ELATED - DEPRESSED

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	7.11	2.59	0.015	(1.9, 16.4)
Control	-1.07			

TABLE 29 D CONFIDENT - UNSURE

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	5.44	1.06	0.30	(-2.3, 3.2)
Control	2.07			

TABLE 29 E ENERGETIC - TIRED

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	7.72	2.58	0.017	(1.6, 14.8)
Control	-0.47			

TABLE 28 9 CLEARHEADED - CONFUSED

Group	Mean Diff.	t	P Value	95% C.I.
Exercise	4.72	0.76	0.45	(-4.3, 9.3)
Control	2.20			

Two sample t-tests and confidence intervals revealed a greater average improvement in the elated - depressed and energetic - tired factors for the exercise group compared with the control group. Although the exercise group showed greater improvements than the controls for the other mood factors, the improvements were not significantly greater.

CHAPTER 5

DISCUSSION

Section 5 Cardiovascular Fitness

5. 1. 1. Training Effect

The American College of Sports Medicine (ACSM, 1990) has specified guidelines on the mode, intensity, duration and frequency of exercise necessary to bring about improvements in cardiovascular fitness. With the exception of frequency of exercise, the present study successfully met these recommendations. Table 12 highlights the mean intensity of exercise each week. The intensity averaged 80% of maximum heart rate which was a sufficient overload to result in the improvements, according to ACSM.

Exercise subjects attended an average of 2.5 Popmobility/Tune up sessions (an average of 30 sessions over 12 weeks). This is slightly below the minimum frequency of 3 sessions per week recommended by the ACSM. However, an average frequency of 2.5 Popmobilty/Tune up sessions over 12 weeks at an average intensity of 79% of maximum heart rate was a suitable stimulus for improvement of $\dot{V}O_2$ max of the exercise group. Johnson et al (1984) compared the effects of twice and thrice weekly dance training on VO_2 max in sedendary women. They reported even larger improvements for the twice weekly group. It is possible that less fit individuals can benefit from exercise programmes with lower frequencies than ASCM recommendations.

All Popmobility and Tune up sessions include a 20 minute aerobic section consisting of activities such as running, skipping, twisting and jumping. Most of the exercising subjects were able to maintain these activities in a rhythmic fashion throughout the 20 minute period. Thus the mode and the duration of the exercise sessions satisfied the recommendations of ACSM. The ACSM recommend 20-60 minutes of continuous aerobic activity which utilises large muscle groups in a rhythmic manner for developing and maintaining cardiorespiratory fitness (ACSM, 1990).

5. 1. 2. Changes in Resting (Pre-Exercise) Heart Rate over the 12 week Period

The exercise and control groups had resting heart rates of 73.56 beats per minute and 71.94 beats per minute respectively. T- tests carried out at baseline revealed no significant differences between the groups (see Appendix H).

The exercise group decreased resting heart rate by an average of 3 beats per minute after 12 weeks of exercise. This reduction was of borderline significance ($p < 0.06$). Some individuals showed large decreases in resting heart rate and 3 individuals showed small increases. The control group over the same period, demonstrated a small, non-significant increase in resting heart rate. T-tests carried out on Test 2 results demonstrated no significant differences in resting heart rate between the groups after the 12 week period. The exercise programme did not result in a large decrease in resting (pre-exercise) heart rate.

5. 1. 3. Resting Heart Rate - Comparison with other Studies

The results of this study differed from a similar male study (Grant, 1989). In Grant's study, the exercise group significantly decreased resting heart rate by 11 beats per minute. However, the control group in Grant's study also showed a significant decrease in resting heart rate. Although the change for the exercise group was significantly greater than for the control group (Grant, 1989), a contributory factor in the changes in resting heart rate may be factors such as familiarity of testing procedures and less apprehension from the subjects other than the exercise programme (Shephard, 1987). Another male study (Tanaka et al, 1988) reported a significant decrease in resting heart following 3 months of thrice weekly jogging.The results of the present study are of similar magnitude to those of Williams et al (1986) who reported a reduction (significant) of 4 beats per minute following a 12 week programme of aerobic dance exercise in women. The resting heart rate of the control group (Williams et al, 1986) did not change . Johnson et al (1984) reported average decreases of 10 beats per minute in female aerobic dancers exercising at frequencies of 2 and 3 times per week for 10 weeks. However, there was no non-exercising control group. On the other hand, Edwards et al (1974) found no significant change in resting heart rate in young women following 28 consecutive days of treadmill exercise. The results of studies on men and women support the fact that programmes of aerobic exercise cause reductions in resting heart rate in men and women. Furthermore, exercise programmes which use rhythmic movements, such as aerobic dance, as the exercise mode can result in significant reductions in resting heart rate.

5. 1. 4. Control of Heart rate at Rest and Factors Affecting Resting Heart Rate

Heart rate is controlled by factors intrinsic to the heart and extrinsic (neural and hormonal) factors (Durstine & Pate, 1988). The heart beat itself is regulated intrinsically by the sinoatrial [SA] node (pacemaker) in the heart. The sympathetic nerve endings in the SA node release noradrenaline which causes an increase in heart rate. The parasympathetic vagus nerve releases acetylcholine which causes a reduction in heart rate. At rest, the influences of the vagus nerve are dominant over the sympathetic influences. This results in the heart rate being lowest under resting conditions (Fox, 1980). Scheuer & Tipton (1977) suggest that as well as increases in parasympathetic activity influence, a concomitant decrease in sympathetic tone may explain resting bradycardia.

However, resting (or pre-exercise) heart rate can be increased by factors such as high temperatures, anxiety, or eating a heavy meal (Shephard, 1987). In the present study, temperature was maintained between 20 - 22° C and all subjects were advised, in advance, to avoid eating for 2 - 3 hours before testing. However, it is possible that subjects were anxious, during the testing peroids. Anxiety may have caused increases in heart rate in some subjects. Additionally, it is reported (Durstine & Pate, 1988) that heart rate often increases in anticipation of exercise (controlled by the limbic system and caused by activation of sympathetic cardioaccelerator nerves and inhibition of the vagus nerve). This may explain the small, only marginally significant reduction in pre-exercise heart rate following 12 weeks of exercise.

5. 1. 5. Sub-maximal Heart Rate

It was assumed that all subjects had reached steady state since the heart rates measured in the final minute of the bicycle test only varied between 2 - 3 beats per minute. T-tests carried out at base line, showed no difference between the groups (see Appendix H). The exercise group demonstrated average decreases of 8, 9 and 13.5 beats/minute for the first, second and third* workloads respectively. The control group demonstrated virtually no changes in the first two workloads, but showed a decrease of 3 beats per minute, which was of borderline significance ($p < 0.06$) in the final load from Test 1 to Test 2. However, a two sample t-test demonstrated that the average improvement shown by the exercise group was significantly greater ($p < 0.001$).

* The exercise group was re-tested at a higher workload than the control subjects, so the heart rate at 75 Watts was interpolated for each exercise subject, since this was the level used for the final workload for the control group. This interpolation was carried out to allow the statistical comparisons.The total testing time was kept constant for all subjects on both testing occasions, since mood state was being assessed immediatetly after physiological testing. This controlled for any acute effects the exercise may have on mood. T-tests carried out on Test 2 results demonstrated that the groups were significantly different in sub-maximal heart rates at 75 watts on the bicycle ergometer test (see Appendix H). The 12 week exercise programme resulted in significant sub-maximal bradycardia in exercise subjects.

5. 1. 6. Sub-Maximal heart Rate - Comparison with Other studies

These reductions in sub-maximal heart rates for the exercise group are slightly less than those found in the male study by Grant (1989), where reductions of 12, 12 and 17 beats/min for the first, second and final workloads, respectively were reported. However, Clausen (1977) states that the magnitude of decrease in sub-maximal heart rate is dependent on initial fitness levels, duration, intensity of exercise and on programme length. Exercisers in Grant's study (1989) exercised at a higher intensity than the present exercise group (88% versus 79%), although the duration was identical. The lower training intensity in the present study may account for the smaller decrease in sub-maximal heart rate in the present subjects. Williams & Morton (1986) reported reductions of 15 beats per minute for female subjects at the same sub-maximal workload following 12 weeks of aerobic dance training. Other studies in women have confirmed these findings (Flint, Drinkwater & Horvath 1971; Kilbom, 1971; Hanson & Nedde, 1974; Massicote et al, 1979; Johnson et al, 1979). All of these studies have reported average reductions of between 10 - 17 beats per minute for women following aerobic training. Massicote et al (1979) reported similar reductions in men (between 8 and 15 beats per minute) and women (between 11 and 17 beats per minute). They (Massicote et al, 1979) concluded that the same training adaptations in sub-maximal heart rate occur in men and women.

5. 1. 7. Factors Influencing Sub-Maximal Heart Rate

As well as training-induced effects, sub-maximal heart rates are affected by environmental factors such as temperature (Rowell, 1974), anxiety, unfamiliarity of equipment and circadian rhythms. The laboratory temperature was (with one exception) maintained between 20 and 22°C. No control subjects were tested on the day that the temperature was low, so it is unlikely that changes in temperature caused the small decrease in sub-maximal heart rate for the final workload in the control group. To eliminate circadian rhythm problems, subjects were re-tested within 2 hours of initial testing, therefore another factor must be responsible for the changes experienced by the control group. Shephard (1987) suggested that subjects become more familiar with the experimenter, thus affecting sub-maximal heart rates. This effect may be due to a decrease in anxiety. It is also possible that a decrease in sub-maximal heart rate can be attributed to increased mechanical efficiency during the bicycle test (a learning effect). To summarise, the control group may have reduced sub-maximal heart rates in the final workload on the aerobic test due to greater familiarity with the experimenter, equipment or a decrease in anxiety. The exercise programme resulted in reductions in sub-maximal heart rate during the final workload of the bicycle test. Subjects exercised at between 75 - 85% of their maximum heart rate during this workload. This is similar to the intensity of exercise recorded from heart rate during the fitness sessions throughout the exercise programme, so sub-maximal heart rate during Popmobility and Tune-Up sessions will be lower for a given oxygen consumption after 12 weeks.

5. 1. 8. Possible Mechanisms in the Reduction in Sub-Maximal Heart Rate

Reductions in sub-maximal heart rate may arise due to changes in several variables, central and peripheral.

5. 1. 8. (a) Central Adaptations

Sub-maximal cardiac output is reported to slightly decrease (Ekblom, Astrand & Saltin, 1968) or remain constant (Blomqvist & Saltin, 1983; Ehansi, 1987). All of these studies reported an increases in sub-maximal stroke volume folllowing training.If sub-maximal cardiac output remains constant or is slightly increased, and sub-maximal stroke volume is increased, then heart rate will be decreased as a result of these adaptations, since cardiac output is the product of stroke volume and heart rate. There are several factors which can cause an increase in stroke volume. Stroke volume is influenced by the preload (the load on the heart before contraction), the afterload (the load on the heart after contraction) and the heart's contractility. Preload can be enhanced by an increase in left ventricular diastolic compliance (or the ability of the chamber to accept blood). Increased contractility of cardiac muscle is also another possible explanation for enhanced stroke volume found in endurance trained subjects. However, Blomqvist & Saltin (1983) indicate that most human studies do not demonstrate enhanced contractility following training.

Trained individuals normally have a decreased heart rate at rest and during sub-maximal exercise, due mainly to an increase in parasympathetic activity (Kenny, 1985) resulting in an increased filling time for the heart. This increased filling time results in an increased diastolic volume which will enhance the contractile potential of the cardiac muscle and increase the volume of blood ejected per beat, according to the Frank-Starling mechanism. Blomqvist & Saltin (1983) suggest that an increased end diastolic volume is the most important factor assocoited with the increase in stroke volume. Also, increases in blood volume have been shown after aerobic training in middle-aged men (Saltin, Hartley, KIlbom et al, 1969). Increased volume results in an increased venous return which can enhance preload.

Aerobic training is associated with a decrease in peripheral resistance or afterload during exercise. This reduction in peripheral resistance during sub-max exercise wiil cause an increase in sub-maximal stroke volume and a decrease in mean exercise blood pressure (Fagard, 1985).The decrease on blood pressure during-maximal exercise will result in a reduction in afterload. Although the mechanisms responsible for reductions in peripheral resistance are not clear, total peripheral resistance may be reduced by a reduction in sympathetic tone (Astrand & Rodahl, 1986) or an increase in vascular space as a result of a development of the capillary network (Ingjer & Brodahl, 1978). It has been suggested that reductions in sub-maximal heart rate with aerobic training may be brought about by a combination of increased parasympathetic activity and decreased sympathetic activity (Ekblom, Kilbom & Soltysiak, 1973; Fox, 1980) or by a decrease in the activity of the pacemaker (Blomqvist & Saltin, 1983; McArdle et al, 1986).

(b) Peripheral Adaptations

Research where exercise trained and untrained limbs have been compared has shown that reduction in sub-maximal heart rate only takes place with the trained limb (Saltin, Nazar, Costill et al, 1976). This suggests that adaptations within the muscle have taken place. Possible peripheral adaptations which have been suggested are : A reduction in blood flow to the working muscles (Clausen,1977); an improved ability of the muscles to extract oxygen (Hollosky, 1973); increased capillary density within the muscle (Astrand & Rodahl, 1986); increased mitochondrial volume and increase in oxidative enzymes (Astrand & Rodahl, 1986).

The sub-maximal bradycardia experienced by exercise subjects in the present study may have been a result of increased stroke volume, an increase in parasympathetic activity or any of the peripheral adaptations mentioned above.

5. 1. 9. Predicted $\dot{V}O_2$ max.

The exercise group had an initial predicted VO_2 max of 1.84 L/min (28.68 ml/kg/min) at Test 1. These values are typical for sedentary women in the 30 - 40 age group (CSTF, 1986). T-Tests carried out at baseline revealed no differences between the groups. After training, predicted VO_2 max had increased to 2.14 L/min (33.75 ml/kg/min). This represents an increase of 16.3% for the prediction of absolute VO_2 max and 17.7% when corrected for weight. Two sample t-tests of the differences demonstrated that the exercise group showed a greater average improvement in predicted $\dot{V}O_2$ (L/min) and $\dot{V}O_2$ max (ml/kg/min) [$p < 0.05$]. Although the increases in predicted VO_2 max (absolute and corrected for weight) were significantly greater for the exercise group, t-tests carried out on Test 2 measures revealed a significant difference ($p < 0.05$) between the groups in absolute $\dot{V}O_2$ max (L/min), but when corrected for weight, the difference between the groups at Test 2 was not significant ($p= 0.09$). This non-significant result in predicted $\dot{V}O_2$ max, when corrected for weight, cannot be due to changes in control group weight or predicted $\dot{V}O_2$ max (a loss of 0.11 kg and an increase of 0.02 L/min for predicted $\dot{V}O_2$ max). The non-significant result is more likely to be due to low statistical power in the between groups comparison.

The increase in $\dot{V}O_2$ max in the present study is slightly less than documented by Astrand & Rodahl (1986) who reported that sedentary subjects can show increases of between 20% and 30% in $\dot{V}O_2$ max. There was virtually no change in predicted $\dot{V}O_2$ max in the control group over the same period. No change was expected, since the control group did not report any significant changes in their activity levels over the 12 week period.

5. 1. 10. $\dot{V}O_2$ Max - Comparison With Other Studies

The magnitude of improvement found in the present study was slightly less than that found in a similar study on men (Grant, 1989) where an improvement of 20%

was reported. However, the mean intensity of exercise for the male study was higher than the intensity reported in the present study (88% versus 79%). The litre/min results in the present study show similar improvents to other studies on women with similar initial $\dot{V}O_2$ max values (Table 30). The 34% improvement reported by Edwards (1974) was possibly because the subjects had initial $\dot{V}O_2$ max values which were low for women in this age group. Additionally, subjects exercised on consecutive days (a frequency of 7 days per week) during the programme. Wenger & Bell (1986) suggested that a higher frequency should result in better improvements. Pollock (1973) suggests that middle-aged subjects show smaller increases in $\dot{V}O_2$ max than younger subjects following training. However, the exercise group in the present study have demonstrated increases in $\dot{V}O_2$ max (litres/min) which are equal or higher than other studies on younger subjects (Table 30). Moreover, the range of individual improvement in the present exercise group was very broad (improvement ranged from 0% to 42%) and the highest improvement occurred in a 42 year old subject. However, this subject had a very low initial predicted $\dot{V}O_2$ max value.

Table 30 - Effects of Aerobic Training on VO_2 max in Women

	SUBJECTS		EXERCISE PROGRAMME				VO2max(ml/kg/min)			
Study	N	age	Length	Freq	Dur	Int	Mode	Test 1	Test 2	%incr
Edwards (1974)	6	18	4	7	15	75% HRmax	treadmill	26.18	35.08	34%
Rockefeller et al (1979)	21	19-25	10	3	40	63% VO2max	aerobic dance	34.38	38.79	12.83%
Vaccarro et al (1981)	20	21	10	3	45	NR	aerobic dance	31.11	38.24	23%
Brownell et al (1982)	37	35	10	3	15-20	70% HRmax	YMCA Ex	30.5	33.2	9%
Williams et al (1986)	25	27	12	3	45	85% HRmax	aerobic dance	35.3	40.8	15.6%
Frey et al (1982)	16	22	10	3	30	70% HRmax	bicycle ergometer	28.5	33.0	16%
Williford et al (1988)	10	23	10	3	45	60-90% HRmax	aerobic dance	34.68	38.94	12.3%
McCord et al (1989)	16	21	12	3	45	70-75% HRmax	aerobic dance	38.38	41.3	8%
Present (1991)	22	36	12	3	30	80% HRmax	jog/skip/ jump/	28.68	33.75	17.7%

[Length in weeks; freq=sessions per week; dur=mins per session; int=intensity]
NR = Not reported

5. 1. 11. Possible Mechanisms for changes in $\dot{V}O_2$ max.

Since $\dot{V}O_2$ max is the product of cardiac output and a-v O_2 Diff, then improvements in the oxygen transport system will take place due to an increase in cardiac output and/or a-vO_2 Diff (Ekblom et al, 1968). However, it is suggested that most of the increase in $\dot{V}O_2$ max in women is due to an increase in maximal cardiac output (Kilbom, 1971). No improvements in maximal a-vO_2 difference was reported for women following aerobic training, consisting of bicycle ergometer exercise 2-3 times per week at 70 % of maximal heart rate (Kilbom, 1971). Possibly, higher intensity and frequency of exercise may result in improvements in maximal a-vO_2 diff in women. However, no further studies to date have reported maximal a-vO_2 diff adptations to training in women. Improvements in the efficiency of the oxygen transport system may be due to central or peripheral adaptations.
Improvements in maximal cardiac output wiil arise from an increase in maximal stroke volume (Rowell, 1975), since maximal heart rate shows either no change or a slight decrease following aerobic training. Increases in maximal stroke volume may be due to an increase in blood volume, which will result in a greater venous return and greater ventricular volume. Training may increase the size of the left ventricle, resulting in a greater ejection of blood per beat (Astrand & Rodahl, 1986). However, some studies on animal models

have reported that an increase in maximal stroke volume may be due to increased contractility of the heart muscle without an increase in chamber size (Lamb, 1978).

Although not evident in women, increases in a-vO_2 Diff with training may be due to an increase in myoglobin content of trained muscle and an enhancement in the diffusion gradient of oxygen between the capillaries and the active muscle (Lamb, 1978). Endurance training is also reported to increase capillary density, which will result in a shorter diffusion distance and increased diffusion time, thereby increasing oxygen extraction in the active muscles (Vander et al 1975). These adaptations to training do not appear to be gender specific. Indeed Ingjer & Brodal (1978) have demonstrated that endurance trained women have considerably higher capillary to fibre ratios than untrained women (1.69 and 1.11 respectively). In addition, aerobic training causes an increase in the number and oxidative capacity of mitochondria (Hollosky, 1973). This results in a trained individual having the ability to sustain longer periods of exercise at a given VO_2 (Hollosky, 1973).

With the possible exception of changes in maximal a-vO_2 diff, the adaptations described above apply to men and women. It would appear that the response to training is similar for men and women (Wilmore & Thomas, 1987).

5. 1. 12. Summary

A 12 week programme of exercise carried out 3 times per week, 30 minutes per session at approximately 80% of maximum heart rate is a sufficient stimulus to cause significant improvements in aerobic power and sub-maximal response to exercise in previously sedentary women. However, only a small favourable change was found in resting heart rate.

Section Two

Abdominal Endurance

5. 2. 1. Sit ups - Pre and Post - Training Values

The exercise and control groups completed on average 19.29 and 19.38 sit ups per minute respectively at Test 1. These values would place both groups in an "average " category (Canadian Standard Test of Fitness, 1986 - see table 2). The exercise group significantly ($p < 0.001$) increased the average number of sit ups performed per minute to 26.06, placing them in an "above average" category at Test 2. The control group also showed a significant improvement at Test 2 (21.56 per minute, $p < 0.005$), although they were still categorised as "average". 95% confidence intervals demonstrated that the average increase was between 5 and 8 repetition for the exercise group and between 1 and 3 for the control group. Additionally, a two sample t-test showed that the average increase for the exercise group was significantly greater than the increase in the control group ($p < 0.001$). A t-test on Test 2 results demonstrated that although the change in sit-up scores was significantly greater for the exercise group, the groups were not significantly different after 12 weeks. The improvement shown by the control group was probably due to a practise effect. It is possible that on the first testing occasion, subjects did not know how to pace themselves in order subjects did not know how to pace themselves in order to allow them to exercise at a pace which would allow maximal effort for one minute. By Test 2, subjects were familiar with the procedure and were able to start off at a more appropriate pace. In addition, control, as well as exercise subjects on the second testing occasion may have had motivation to increase their initial scores. Although some of the improvement was possibly due to motivational and practise effects, results show that the exercise programme increases local muscular endurance in the abdominal region, but was not enough to result in a significant difference between the exercise and control groups. An exercise programme of longer duration may have resulted in even more favourable changes in abdominal endurance of participants.

5. 2. 2. Sit Ups - Comparison with Other Studies

The finding of this study are similar to other studies which have assessed sit ups after a programme of exercise which include abdominal exercise (Capen, 1950; Marcinik et al, 1985; Grant et al, 1989). All of these studies have shown a significant improvement in abdominal endurance following training. The present study showed almost identical improvement to those reported by Grant (1989) who used a similar exercise programme on similarly aged sedentary men. A study which compared the responses of men and women to an exercise programme (Massicote et al, 1979) reported similar improvements in abdominal endurance in men and women after training.

5. 2. 3. Possible Mechanism for Improvement in Abdominal Endurance

With appropriate training, muscles increase their capacity to exert a force over a period of time (Fox & Mathews, 1981). For improvements in local muscular endurance to take place, there must be a demand placed on the appropriate muscles. Overload on the muscles is the required stimulus for increased muscular endurance. As the body adapts, more overload is required. The overload principle is emphasised in the University sessions. The local muscular conditioning sections of both Popmobility and Tune-up sessions always contain specific exercises for the abdominal region. In addition, other movements in other parts of the session (such as jogging, high-knee jogging, skipping and burpees and various movements carried out during Popmobility) are likely to use the abdominal muscles indirectly and so will have an effect on abdominal endurance. High intensity training, in general, produces an increase in the activity and concentration of glycolytic enzymes compared with the untrained state (Fox, Bowers & Foss, 1989). This increased glycolytic capacity will ultimately produce more ATP energy derived from anaerobic glycolysis. This will contribute to the improved performance of activities which rely on anaerobic glycolysis (Fox fitness sessions normally require a continual, near-maximal effort lasting between 30 and 60 seconds, therefore the dominant energy system for such activities (including a sit up test) will be the lactic acid system. Sit up exercises performed at near-maximal effort (ie short duration/high intensity) as during the fitness sessions, will almost certainly have trained the lactic acid system, which would, in turn, have resulted in improvements in the sit ups performed at Test 2.

The aerobic component of the exercise sessions in the present study is likely to have had an effect on the muscular endurance of the subjects. Aerobic training normally produces an increase in the number of mitochondria and in the concentration of oxidative enzymes within the muscle (Ingjer, 1979). In addition, an enhanced capillary network in the muscle, as a result of training (Ingjer, 1979) will result in a reduction in the distance between the cell interior and the blood and a more efficient removal of metabolic waste products. All of these factors should contribute to an improvement in muscular endurance.

5. 2. 4. Summary

The abdominal exercise within Tune up and Popmobility sessions, if attended 3 times per week, can increase abdominal endurance in women, as measured by a sit up test.

Section Three- Flexibility

5. 3. 1. Sit and Reach Scores - Pre and Post- Test Measures

The mean sit and reach scores for the exercise and control groups at test 1 were 34.32 cm and 35.94 cm respectively, placing both groups in an "average" category (Canadian Standardised Test if Fitness, 1986 - see table 3). The exercise group significantly ($p < 0.001$) increased sit and reach score to a mean of 37.91 cm at Test 2, placing them in an "above average" category for women aged 30 - 39. The control group showed a very small, non-significant average increase in sit and reach scores at test 2. Three individual subjects demonstrated exceptional degrees of hamstrings/low back flexibility at baseline (with scores of 48, 48 and 54 cm respectively). It was not anticipated that these subjects would show any increase in sit and reach scores. Indeed, this was found to be the case. Since subjects were in an "average" category for sit and reach scores at baseline, a large increase in scores was not expected. Moreover, the flexibility section in Popmobility and Tune-Up sessions only lasts for 5 minutes, during which time the major muscle groups are statically stretched. Only 2 - 3 stretches per session emphasise hamstrings and lower back muscles. However the results of this study show that this time is sufficient to elicit an improvement in this region of the body.

5. 3. 2. Sit and Reach Scores - Comparison with Other Studies

The present study did not demonstrate as marked an improvement in sit and reach scores as a similar exercise study on sedentary men (Grant, 1989) The exercising men showed a large increase of 6 cm after a 10 week programme of Tune-Up sessions. However, although the baseline score for the men was also "average", (see figure 3) it was at the lower end of the range for 30-40 year old men. The female average was at the upper limit of the "average" range , so the women had less potential for improvement than the men.

4. 3. 3. Improvements in Flexibility - Possible Mechanisms

When a muscle is stretched, most of the resistance to stretch is from connective tissue and not from the muscle itself (Sapega, 1981). Connective tissue has two material properties and can undergo two types of deformation. The elastic deformation is recoverable, whereas the viscous element allows permanent deformation. When stretched, connective tissue behaves as if it has both viscous and elastic properties. However, various factors determine the proportion of viscous (plastic) and elastic stretch. The viscous element predominates under lower forces, longer duration stretches and higher temperatures. The opposite is true for the elastic element. The former conditions are reorted to give optimal improvements in flexibility (Sapega. 1981). The flexibility section is placed at the end of both Popmobility and Tune-Up sessions, so the connective tissue around the muscles should be warm. Additionally all stretches are static (low applied force) and are held for approximately 10 - 20 seconds in the stretch position. These conditions should maximise the viscous element of stretch and minimise the response of the stretch reflex and thus promote an increase in flexibility.

5. 3. 4. Summary

Five miutes of flexibility carried out 3 times per week can improve flexibility, as measured by a Sit and Reach Test.

Section Four

Body composition

5. 4. 1. Estimated Percentage Body fat - Baseline Values

The estimated percentage body fat at Test 1 was 30.70% for the exercise group and 28.71% for the control group. The exercise group was marginally in excess of the accepted level of body fat (between 20 - 30 %) for women (Katch & McArdle, 1988). However this level is within the average range for a female Glasgow population in the 30 - 40 year age range (Durnin, 1974). The percentage fat of the control group is within Katch & McArdle's acceptable range. T-tests on Test 1 results showed that the groups were not significantly different at baseline. The exercise group significantly decreased percentage body fat to 29.03 %, a reduction of 1.67 %. At Test 1 body weight for the exercise group was 64.26 Kg and 62.00 Kg for the control group. The exercise group decreased by a small, but significant amount (0.78 Kg) at Test 2. A t-test on Test 2 results showed that, although the exercise groups decreased weight and body fat levels, the groups were not significantly different after 12 weeks.

At Test 1, 30.70% body fat corresponds to a fat weight of 19.73 Kg. Assuming that all the weight loss was fat, the fat weight at Test 2 would be 18.95 Kg. This fat weight would be equivalent to 29.88 % fat, a loss of 0.19 % fat. The predicted fat loss from the caliper measurement was 1.67 % for the exercise group. There are several possible explanations for this discrepancy between fat loss and weight loss.

5. 4. 2. Experimental Error

All measurements on all subjects were taken by the experimenter which should increase test-retest reliability. Error in skinfold measurement is a possible source of error. However, a pilot study (see Appendix G) carried out earlier using a varied sample, demonstrated that the experimenter was reliable ($r = 0.99$) at taking skinfold measurements. The experimenter had practised the skinfold measurement technique for some time before the study and was competent. In addition, Hyner et al (1986) have shown that inexperienced individuals can measure skinfold as reliably as individuals with a lot of experience.

Instrument error is another possibile explanation for any discrepancies. However, the same caliper was used throughout the study period and was calibrated before each testing period, so it is unlikely that much error would arise from the apparatus.

5. 4. 3. Subjects with High Body Fat

Three subjects initially had estimated percent body fat which exceeded 35 %. In these subjects it was particularly difficult to take measurements at the subscapular skinfold site. These subjects all had tight skin in this area and it proved difficult to pinch the fold. These subjects, however, tended to lose fat from the supra-iliac and triceps sites, so the subscapular measurements did not change much from one test to the next. Although this is a possible source of error, the small number of subjects encountered would not result in such a large discrepancy.

5. 4. 4. Changes in Body Composition

The larger decrease in percentage body fat, as assessed by skinfold prediction, than predicted by the weight loss may be due to a concomitant increase in lean body tissue following the exercise programme. Using the esimated percentage body fat as measured by the skinfold caliper, would produce an estimate for lean body mass of 44.40 Kg at Test 1 and 45.05 Kg at Test 2, a gain of 0.65 Kg.

5. 4. 5. Choice of Skinfold Sites

All 4 sites used to equate body fat are upper body sites. Most women typically have a "gynoid" fat distribution (Wingard, 1990) with most of their body fat located on the hips and thighs, so measurement of skinfolds on lower body locations may have provided a better reflection of the true fat loss of the exercising subjects. Durnin & Womersley (1974) devised their equations from a sedentary Glasgow population, so the equations should be suitable for initial testing of the exercise group. Later work (Sinning et al, 1984) which used Durnin and Womersley's method on an athletic female population, found that the percentage body fat was over-estimated by 4 %, on average (when compared to densitometry). It may be necessary to use a method of estimation which includes lower body sites when assessing the effects of an exercise programme on fat loss for women.

5. 4. 6. Energy Balance

Limited resources did not allow any quantitative assessment of food intake. However, a food freqency questionnaire (Appendix D) was completed at Test 1 and Test 2 by all subjects. The food frequency questionnare (Appendix D) assessed the type and quantity of food normally consumed by the subjects. The questionnaires were hand scored and analysed by hand. There were no significant differences in the type of food consumed. Most subjects reported that they had not changed the type or frequency of food normally consumed during the study period. A few exercise subjects reported that they consumed larger quantities of food at Test 2.

In order to allow negative energy balance, the energy balance equation must be unbalanced by either a decrease in intake or an increase in expenditure. the fact that the subjects in the present study had been previously sedentary, a 12 week exercise programme is likely to have increased energy expenditure. An undergraduate research exercise (Armstrong & Sutherland, 1990) assessed the energy cost of Popmobility and Tune-Up sessions in women aged below 30 years. Mean expenditure during Popmobility and Tune-Up was 236.6 Kcal and 254.1 Kcal respectively. Of the total sessions attended, 59 % were Popmobility and 41 % were Tune-Up sessions. Assuming that the net energy expenditure of the present exercise subjects was the same as those in Armstrong & Sutherland's study, the average net energy expenditure at the fitness sessions for subjects in the present study was approximately 7313 Kcal. [The following calculation was used : **Estimated energy expenditure** = 0.59 (proportion of Popmobility sessions attended) * 30 (mean number of sessions attended) * 236.6 (energy cost of a Popmobilty session) + 0.41 (proportion ot Tune-up sessions attended) * 30(mean number of sessions attended) * 254.1(energy cost of a Tune-up session) kilocalories]. This equates to a fat loss of 1.05 Kg. Actual weight loss (0.79 Kg) was less than this prediction from energy expenditure, but the percentage fat loss from this prediction was less than the loss predicted from the caliper measurements.

These findings suggest that lean body mass is affected by 3 Popmobility and/or Tune-Up sessions per week.

5. 4. 7. Body Composition - Comparison with Other Studies

Epstein & Wing (1980) concluded in their review that net energy expenditure and fat loss are not in close agreement. This fact is evident in the present study. The results of this study showed a larger drop in percentage body fat than was predicted from weight loss. Other studies in women have shown a similar pattern, that is, an exercise programme has resulted in a small weight loss, but a significant decrease in percentage body fat (Frey et al, 1982; Johnson et al, 1983; McCord et al. 1989). Larger decreases in percent body fat, than in the present study, were reported by McCord et al (1989) and Johnson et al (1979). In contrast to the present and other studies, a 12 week programme of aerobic dance (Williams et al, 1989) resulted in a significant increase in body weight and body fat. The present study showed a greater fat loss than Grant's study which used a similar exercise programme in men (Grant, 1989). He reported a loss 0.6% compared to 1.67% reported at present.

Both Williams et al (1986) and McCord et al (1989) reported significant increases in lean body mass following programmes of aerobic exercise. Although not directly measured in the present study, an increase in lean body mass would result in a smaller loss in total body weight than expected from the fat loss. This was in fact the case, so it is likely that the present exercise subjects did experience an increase in lean body mass.

A comparison with other female studies is presented in Table 31.

5. 4. 8. Summary

A 12 week exercise programme can result in small, but significant decreases in body weight and body fat in women.

Table 31 Body Composition - Aerobic Exercise Training Studies in Women

	SUBJECTS		EXERCISE PROGRAMME						BODY COMPOSITION		
Study	N	age	Length	Freq	Dur	Int	Mode		Test 1	Test 2	P Value
Johnson et al	11	24	10	3	30	70% HRmax	aerobic dance	W F	60.4 28.9	58.4 25.8	n.s. <0.001
Massicote et al (1979)	11	33	20	3	20	70-75% VO2max	Run/ walk	W F	58.4 25.6	56.6 23.5	<0.01 <0.01
Vaccarro et al (1981)	20	21	10	3	45	NR	aerobic dance	W F	55.6 26.6	56.0 27.2	n.s. n.s.
Frey et al(1982)	16	22	10	3	30	70% HRmax	bicycle ergometer	W F	57.3 28.5	57.0 26.0	n.s. <0.005
Williams et al (1986)	25	27	12	3	45	85% HRmax	aerobic dance	W F	60.8 28.3	62.1 27.3	<0.01 <0.01
Williford et al (1988)	10	23	10	3	45	60-90% HRmax	aerobic dance	W F	60.7 27.0	58.3 26.4	n.s. n.s.
McCord et al (1989)	16	21	12	3	45	70-75% HRmax	aerobic dance	W F	60.3 25.2	60.0 21.2	n.s. <0.05
Present (1991)	22	36	12	3	30	80% HRmax	jog/skip/ jump/	W F	64.3 30.7	63.5 29.0	<0.05 <0.05

[Length in weeks; freq=sessions per week; dur=mins per session; int=intensity
W = Weight in Kg ; F = percentage body fat]

Section 5

5. 5. Blood Pressure

5. 5. 1. Baseline Levels

The mean blood pressure for the exercise and control groups at test 1 was 121/79 mm Hg and 119/78 mm Hg respectively. There were no differences in blood pressure between the groups at Test 1. These levels respresent blood pressures which are within the normal range, so would be categorised as being normotensive. With one exception, all subjects had blood pressures below 140/90 mm Hg. This subject, whose initial blood pressure was 148/100 mm Hg, required medical permission to enter the exercise programme.

The mean blood pressure at Test 2 for the exercise and control groups was 119/73 mm Hg and 117/73 mm Hg respectively. This represents no change in systolic blood pressure, but a significant reduction in diastolic blood pressure for both groups. Groups were analysed on Test 2 results, but there were no significant differences between the groups (see Appendix J).

5. 5. 2. Blood Pressure - Comparison with Other Studies

The present study has followed the pattern of the studies of Bonnano et al (1974) and Kukkonen et al (1982) on middle-aged men, where neither exercise nor control groups significantly altered systolic blood pressure, but both significantly decreased diastolic blood pressure. These results mean that the decrease shown by the exercise group cannot be attributed to the exercise programme. Moreover, they support the need for controlled studies. In a similar male study (Grant, 1989) subjects showed no significant change in systolic or diastolic blood pressure following a 10 week exercise programme. No studies which individually dealt with the effects of exercise on normotensive women could be found.

5. 5. 3. Possible Mechanisms for Reduction in Blood Pressure

Since mean arterial blood pressure is the product of peripheral resistance and cardiac output, reductions in blood pressure must be due to decreases in one or both of these factors. The exercise group experienced significant decreases in sub-maximal heart rate and diastolic blood pressure, suggesting a reduction in sympathetic tone. Although the control group decreased diastloic blood pressure by a similar degree, this group only demonstrated a small reduction in sub-maximal heart rate. Fagard (1985) stated that although a reduction in autonomic activity may be partly responsible for training-induced bradycardia, the extent to which decreased autonomic activity influences blood pressure is not certain.

Although it is possible that a reduction in sympathetic activity occurred following a 12 week programme of exercise this cannot explain the decrease in diastolic blood pressure experienced by the controls.

5. 5. 4. Reduction in body Weight

A reduction in body weight as a result of endurance training may indirectly cause a decrease in resting blood pressure. In a review by Tipton (1984), he commented that many researchers associate reductions in body weight with decreases in blood pressure. Krotkiewski et al (1979) reported that obese hypertensive females who lost weight reduced blood pressure by a smaller amount with 24 weeks of endurance training than those who did not lose weight. However they found a positive association between initial insulin levels and subsequent reduction in blood pressure rather than an association between initial body weight and reduction in blood pressure. Also subjects with high initial triglyceride levels showed greater decreases in blood pressure (Krotkiewski et al, 1979). The association between weight loss and decreases in blood pressure probably arises from the fact that increased weight is normally a risk factor for hypertension. Paffenbarger et al (1978) in a study of the prevalence of hypertension in Harvard alumni came to the following conclusion : The heavier the individual for a given height, the greater the possibility of becoming hypertensive. The mean weight for the groups in the present study was not particularly high and neither group showed large weight loss. In addition, triglglyceride levels were normal at baseline and did not change significantly after 12 weeks, so neither of these factors can explain the decreases in diastolic blood pressure excperienced by both the exercise and control groups. Fagard et al (1985) reported that blood pressure can be reduced following aerobic training even if there is no fall in body weight. If body weight decreases by a large amount, it is likely that arm size will be reduced. This may mean that the cuff size used originally for measurement of blood pressure may no longer be appropriate. The use of an inappropriate cuff can result in measurement error.

5. 5. 5. Training Stimulus and Changes in Fitness

Tipton (1984) suggested that exercise at a minimum of 70 % of maximum heart rate carried out 3 times per week should be an adequate stimulus to cause reductions of between 5 - 20 mm Hg in resting sytolic and diastolic blood pressure if the initial pressure is in excess of 125/85 in normotensives. However, decreases in blood pressure as a result of improvements in fitness can be ruled out in the present study, as the control group showed a similar reduction to the exercise group in diastolic blood pressure, without any changes in fitness. In general, from male research, reductions in blood pressure following endurance training are rare.

5. 5. 6. Summary

Although significant reductions in diastolic blood pressure occurred in the exercise group following 12 weeks of exercise, the reduction cannot be attributed to the exercise programme, since control subjects experienced a similar reduction in diastolic blood pressure. Systolic blood pressure did not change following 12 weeks of exercise.

Section 6

5. 6. Plasma Lipids

5. 6. 1. Total Cholesterol - Baseline Levels

The total cholesterol levels were 5.67 mmol/L and 4.99 mmol/L for the exercise groups and control groups respectively at baseline. The level for the control subjects would be categorised as being within the normal range for 30 - 40 year old women. The average level of total cholesterol for Scotland (Smith et al, 1989) for women in the 35-44 age group is 5.6 mmol/L. However, the average level for the exercise group may, according to the European Atherosclerotic Society (EAS, 1987) warrant dietary advice. T-tests carried out at baseline, demonstrated that the apparent differences between the two groups was not statistically significant ($p< 0.05$). The present baseline figures are similar to those reported by Ballantyne et al (1978) who used a similar Scottish population. Although both groups decreased levels of total cholesterol by very small amounts after the 12 week period, the changes were not statistically significant ($p > 0.1$). In fact, the control group ($p=0.17$) demonstrated a larger downward trend than the exercise group ($p=0.73$) in total cholesterol after 12 weeks. This would imply that any changes, however small, cannot be attributed to the exercise programme. One subject in the exercise group had a very high total cholesterol level at Test 1 (8.6 mmol/L) and required medical permission to continue with the exercise programme. This particular subject had a family history of elevated cholesterol levels. She experienced an increase in total cholesterol (9.8 mmol/L) following the exercise programme. The groups were analysed on Test 2 results (see appendix J), but there were no significant differences between the groups.

5. 6. 2. Comparison with Other Studies

The results of the present study agree with the effects of exercise training on plama cholesterol (Ballantyne et al, 1978; Brownell et al, 1982 ; Frey et al, 1982; Williford et al, 1989; Hardman et al, 1991). All of these studies reported only modest, non-significant changes in plasma total cholesterol following exercise training in women. The results of several female studies on training and blood cholesterol levels are presented in Table 32 and show that, in general, aerobic exercise does not lower total cholesterol in women. However, some of these studies did not use control groups.

5. 6. 3. Plasma Triglycerides - Baseline Levels

The exercise group had a mean plasma triglyceride level of 0.98 mmol/Litre and the control group had a mean level of 0.72 mmol/Litre. The exercise group had an initial triglyceride level which was very similar to those reported by Ballantyne (1978) who used a similar Glasgow population. The subject reported earlier in the total cholesterol section as having high cholesterol level also had a much higher triglyceride level than any other subject. Although the control group had a lower mean triglyceride level than the exercise group, the difference was not statistically significant. Analysis on Test 2 results showed that the groups were not significantly different after the 12 week period.

5. 6. 4. Comparison with Other Studies

The results of the present study agree with those obtained in a similar study on men (Grant, 1989) where both exercise and control groups showed very small non-significant decreases in plasma triglycerides afetr 10 weeks. The present results are also consistent with the results of most other studies on women. Only one study listed (Ballantyne et al, 1978) reported a significant decrease in baseline levels of plasma triglycerides following training. However, the programme length was significantly longer (6 months) than the other studies which lasted between 10 and 17 weeks. It is possible that shorter exercise programmes are insufficient in allowing the adaptations which cause reductions in plasma triglyceride levels in women. Table 33 summarises the effects of exercise training on plasma triglycerides in women.

5. 6. 5. Possible Mechanisms and Interactions which cause decreases in Plasma Triglycerides

Exact mechanisms and cause for reductions in plasma triglycerides have not been firmly established. However, decreases have been attributed to increases in skeletal muscle or adipose tissue activity of lipoprotein lipase [LPL] (Haskell, 1984). LPL is the main enzyme involved in the catabolism (breakdown to free fatty acids) of triglyceride-rich lipoproteins. Another possiblity for the reduction in plasma triglycerides is that there may be a reduction in the synthesis of triglycerides following endurance training (Simonelli & Eaton, 1978). No decreases in triglycerides were found after 12 weeks in the present study. However, since baseline levels were low, significant decreases were not expected.

5. 6. 6. Weight Loss and Trigycerides

Decreases in plasma triglycerides have often been associated with decreases in body fat. Obese individuals normally have higher than normal levels of triglycerides (for example the subjects in the study by Lewis et al, 1976). Vigorous exercise and caloric restiction have similar effects on triglyceride levels (Haskell, 1984). However, elevated triglyceride levels can be lowered by exercise even if there is no change in weight or diet (Haskell, 1984). In addition, the reduced triglyceride levels can be maintained without any change in weight as long as vigorous exercise requiring 300 Kcal or more on at least 2 or 3 occasions during a week is performed (Gyntelberg, Brennan, Hollosky et al, 1977). Subjects in the present study had low baseline plasma triglygeride levels, so a significant decrease with exercise was not expected.

5. 5. 7. Summary

Neither the exercise group or the control group showed significant changes in total cholesterol or plasma triglycerides over the 12 week period.

TABLE 32 Total Cholesterol - Exercise training studies in women

STUDY	SUBJECTS		EXERCISE PROGRAMME					TOTAL CHOLESTEROL	
	N	Age	Len	Freq	Int	Dur	Mode	Test 1	Test 2
Ballantyne et al (1976)	16	Middle Aged	26	3	n.s.	30	Aerobic prog.	5.81	5.65
Lewis et al (1976)	22	n.s.	17	2	n.s.	30	walk/ jog	5.26	5.20
Craig et al (1981)	15	31	10	3	n.s.	30	jog	4.78	4.47
Brownell et al (1982)	37	35	10	3	70% HRmax	30	YMCA aerobic	4.83	4.62
Frey et al (1982)	16	19-29	10	3	70% HRmax	30	bicycle	4.32	4.62
Hill et. al (1989)	22	22-45	52	3	70% HRmax	30	jog	4.63	4.63
Williford et al (1989)	13	23	10	3	60-90% HRmax	30	Aerobic dance	4.58	4.62
Hardman et al (1991)	28	45	52	-	-	-	walk	5.35	5.00
Present (1991)	22	36	12	3	80% HRmax	30	jog/skip hop	5.73	5.67

Len = Length of study (weeks) ; Freq = Frequency (sessions per week)
Int = Exercise intensity ; Total cholesterol measured in mmol/L
n.s. = not specified

Table 33 Plasma Triglycerides - Aerobic Exercise Training studies in Women.

STUDY	SUBJECTS		EXERCISE PROGRAMME					PLASMA TRIGLYCERIDES		
	N	Age	Len	Freq	Int	Dur	Mode	Test 1	Test 2	P Value
Ballantyne et al (1976)	16	Middle Aged	26	3	n.s.	30	Aerobic prog.	1.03	0.76	< 0.01
Lewis et al (1976)	22	n.r.	17	2	n.s.	30	walk/ jog	2.30	2.49	n.s.
Massicote et al (1979)	11	33	20	3	70-85% HRmax	20	Run	105*	95*	n.s.
Brownell et al (1982)	37	35	10	3	70% HRmax	30	YMCA aerobic	1.85	1.92	n.s.
Frey et al (1982)	16	19-29	10	3	70% HRmax	30	bicycle	1.72	1.69	n.s.
Williford et al (1989)	13	23	10	3	60-90% HRmax	30	Aerobic dance	1.47	1.76	n.s.
Present (1991)	22	36	12	3	80% HRmax	30	jog/skip hop	0.98	0.91	n.s.

Len = Length of study (weeks) ; Freq = Frequency (sessions per week)
Int = Exercise intensity ; Plasma Triglycerides measured in mmol/L
except * (mg %) ; n.r. = not reported ; n.s. = non-significant

Section 7

5. 7. Psychological Effects

5. 7. 1. Profile of Mood States - Pre and Post-test Results

(a) Composed-Anxious factor

The mean T score for the composed-anxious factor at Test 1 was 47.19 for the exercise group and 50.13 for the control group. These represent typical scores for a normal population (Lorr & McNair, 1980). A t-test at baseline showed no differences between the groups (Appendix H). At Test 2, the exercise group had significantly increased ($p<0.001$) their mean T score to 54.68. This result represents a decrease in anxiety/ increase in composure. The control group increased their mean T score by 3.80 from Test 1 to Test 2, an increase which was of borderline significance. A two sample t-test and 95 % confidence interval demonstrated that the increase shown by the exercise group was not significantly greater than the increase for the control group. A t-test carried out on Test 2 results confirmed that the groups were not significantly different after 12 weeks on the composed-anxious factor. The 12 week exercise programme did not result in a significant improvement in composed-anxious score compared with a no exercise condition.

(b) Agreeable-Hostile Factor

The mean T score for the agreeable-hostile factor was 46.33 for the exercise group and 47.93 for the control group. The exercise group significantly increased (p<0.02) the mean T score for this factor to 52.79 after 12 weeks. An increase in mean T score represents a decrease in hostility and a change towards a more aggreeable mood state. The control group showed a non-significant increase over the same time period. A two sample t-test and 95 % confidence interval revealed that the exercise group did not show a significantly greater increase than the control group over the 12 week period. The two groups did not differ in the agreeable-hostile mood factor at Test 2 (Appendix J). The 12 week exercise programme did not result in significant improvements in agreeable-hostile score compared with a no exercise condition.

(c) Elated-Depressed

The mean T score for the elated-depressed factor was 47.24 for the exercise group and 47.60 for the control group at Test 1. The groups were not significantly different at baseline (Appendix H). The exercise group had significantly (p<0.005) increased the mean T score to 55.79 after the 12 week exercise programme. The average increase in T scores for the exercisers was between 3 and 13. This result represents an increase in elation/decrease in depression. The control group showed no significant changes. A comparison of the changes over the 12 week period as shown by a two sample t-test demonstrated that the increase shown by the exercise group was significantly greater than that of the control group. Analysis on Test 2 results revealed that the two groups differed in elated-depression scores (Appendix J). The 12 week exercise programme was successful in significantly increasing the elated-depressed score of participants compared with non-exercising controls.

(d) Confident-Unsure

The mean T score for the confident-unsure factor was 47.38 for the exercise group and 47.33 for the control group at Test 1. The groups were not significantly different at baseline (Appendix H). After 12 weeks, the mean T score for the exercise group had significantly increased to 54.10. An increase in mean T score represents an increase in confidence/decrease in uncertainty. The control group showed a non-significant decrease in mean T score. A two sample t-test of the changes demonstrated that the exercise group did not improve significantly more than the control group. Analysis on Test 2 results showed that the groups were not significantly different over the 12 week period (Appendix J). The 12 week exercise programme did not result in significant changes in confident-unsure score compared with a no exercise condition.

(e) Energetic-Tired

The mean T score for the energetic-tired factor was 47.24 for the exercise group and 46.20 for the control group. The groups did not differ significantly at baseline (Appendix H). The exercise group significantly increased the mean T score to 56.58 at Test 2, with mean increases of between 4 and 11. This increase represents an increase in energy/decrease in fatigue. The control group showed a small non-significant increase. A two sample t-test of the changes demonstrated that the improvement shown by the exercise group was significantly greater than that of the control group. A t-test carried out on Test 2 results revealed that the two groups were significantly different after the 12 week period.The 12 week exercise programme was successful in significantly increasing the energetic-tired score of participants compared with non-exercising controls.

(f) Clearheaded-Confused

The mean T score for the clearheaded-confused factor was 51.39 for the exercise group and 50.60 for the control group at Test 1. The groups were not significantly different at baseline (Appendix H).

Neither group demonstrated any signifant changes in this mood factor after 12 weeks. Analysis of Test 2 results demonstrated that the groups were not significantly different after the 12 week period (Appendix J). The 12 week exercise programme did not result in significant changes in clearheaded-confused score compared with a no exercise condition.

5. 7. 2. Summary of Findings

These results demonstrate that exercise training does have a positive influence on certain mood factors of participants following training. The results of this study have found that the exercise group did not differ from the control group in any of the mood factors as measured by POMS, at the start of the programme. The exercisers showed significant improvments in all mood factors except clearheaded-confused following the exercise programme. However, analyses of the changes revealed that the exercisers improved significantly more than the controls only on two mood factors. These were elated-depressed and energetic-tired factors. Analysis of Test 2 measures revealed significant differences in the same factors following the 12 week study period. These results suggest that although the exercisers improved in the other factors, these improvements cannot be attributed to the exercise programme since the improvements were not significantly greater that those for the control group. The only definite positive changes which more likely to be associated with the exercise programme are those in elation/depression and energy/tiredness. It can be seen from the results that the exercise programme can be associated with improvements in elation/depression and energy/tiredness scores.

5. 7. 3. Mood - Comparison with Other Studies

It is difficult to compare exactly the present results with those from other studies, since various instruments for assessing mood were used. However, other studies have reported similar positive influences on mood profiles following aerobic exercise (Blumenthal et al, 1982; Thow et al, 1988; Moses et al, 1989). Morgan & Pollock (1977) suggested that athletes possess an "Iceberg Profile", with higher POMS scores (mean T scores) for vigour and lower scores for depression than the general population. Although the present exercise group did not show this exact profile, the mean T scores for energy and elation were significantly greater than the control group after the 12 week period, thus showing a similar (but not identical) pattern to the athletes reported by Morgan & Pollock (1977), since subjects in the present study were not athletes. The present findings are more comparable to those of Berger & Owen (1983) who reported an "Iceberg Profile" pattern for recreational swimmers.

5. 7. 4. Possible Mechanisms for the Psycholgical Benefits of Exercise

It is not known if exercise per se is responsible for the positive effects often associated with exercise.

There are several hypotheses which attempt to explain the psychological benefits of exercise. Two offer biochemical mechanisms. The other hypotheses offer physiological and psychological explanations.

5. 7. 4.(a) Biochemical Mechanisms

The brain has three main monoamines, serotonin, dopamine and noradrenaline. This hypothesis suggests that exercise causes alterations in one or all of these monoamines (Morgan, 1985). Most work on humans in this area has concentrated on noradrenaline (NA), or its major urinary metabolite 3-methoxy-4-hydroxyphenolglycol (MHPG). Since NA does not cross the blood-brain barrier, MHPG is a convenient method of estimating NA concentration. It must be stressed that peripheral MHPG levels may not correlate well with brain NA levels. However, most human studies have reported increases in MHPG levels following acute exercise (Morgan & O'Connor, 1988).

Noradrenaline is reported to be low in depressed subjects (Buffone, 1984). Several anti-depressant drugs are designed to elevate brain NA levels. This elevation results in a decrease in depression (Morgan, 1985). Research on rats (Weber & Lee, 1968) demonstrated improvements in emotionality following a chronic swimming exercise. Brown et al (1979) found increased serotonin and noradrenaline levels in most brain areas in rats following an 8 week programme of running. The exercising animals were compared to sedentary controls. The facts reported above (increased monoamine levels and decreased emotionality in rats following chronic exercise and decreased depression following drug-induced increases in brain monoamines) suggest that the monoamine hypothesis can be defended, but has yet to be tested in well controlled conditions in humans.

Various opiate peptides (endorphins and enkephalins) are produced by the brain, pituitary and other areas of the body. These peptides produce similar effects to morphine with regard to pain perception and euphoria and utilise the same receptors, in the CNS, as morphine. However, opioid peptides do not cross the blood-brain barrier, so research on central levels of these chemicals has to confined to animal models. Studies on humans measure peripheral levels of peptides, which may, or may not be closely related to central levels. Acute exercise has been reported to cause increases in peripheral endogenous opioids such as beta- endorphin and leucine enkephalin (Carr et al, 1981; Colt et al, 1981; Gambert et al 1981). Improved mood state following exercise has been associated with increased levels of peptide opiates such as endorphins and enkephalins (Janal, Colt, Clark et al, 1981). Additionally, elevated levels of endorphins following an acute bout of exercise has been associated with the "runners high". Moreover, an injection of naloxone (an opioid antagonist) in exercising mice (Christie & Chester, (1982) resulted in withdrawl behaviour. This supports the opioid explanation for the "runners high". On the other hand, other researchers (Farrell, Gates, Makesud et al, 1982; Markoff et al, 1982) have found no relationship between mood and beta-endorphin levels. Despite these equivocal findings and methodological difficulties, the endorphin hypothesis still remains a plausible explanation for mood elevation following exercise.

5. 7. 4.(b) Physiological Mechanisms

Acute exercise is often associated with decreases in tension and anxiety (de Vries, 1981; Raglin & Morgan, 1985). This anxiety reduction may be due to decreases in muscle tension. Morgan has suggested that increases in body temperature caused by exercise may result in decreases in muscle tension, as assessed by emg activity, and anxiety. Raglin & Morgan (1985) reported decreases in state anxiety following a 5 minute shower at 38.5 ^{O}C. Exercise caused similar reductions. Elevation in temperature causes a decrease in muscle tension which can, in turn cause a reduction in anxiety. Morgan & O'Connor (1988) suggested that elevated temperatures may increase brain monoamines which may be another possible explanation for exercise-induced reductions in tension.

5. 7. 4.(c) Psychological Mechanisms

Engagement in an exercise programme may provide a distraction from everyday activities, such as work, which may serve to produce some of the positive benefits of exercise. In other words, the "time out" , rather than the exercise per se, may be responsible for the benefits. Bahrke & Morgan (1978) and Raglin & Morgan (1988) have reported that rest periods with no distractions result in reductions in tension and anxiety. Exercise was found to produce the same effects. However, Raglin & Morgan (1988) found that the effects following exercise persist for longer than rest.

It is possible that chronic exercise may provide subjects with a sense of accomplishment which can increase their self-esteem. Subjects may feel that practise has allowed them to master a task. This idea has been supported by Sonstroem (1984) and Moses et al (1989). It is possible that an increase in aerobic fitness, as experienced by the exercisers in the present and other studies may explain some of the benefits of exercise. The present subjects have, following the exercise programme, an increased perception of available energy for everyday tasks. This increase in perceived energy may be linked to the increase in elation experienced by exercising subjects in the present and other studies. The increased vigour felt in everyday activities possibly made the exercise subjects feel better about themselves. However, non-aerobic exercise programmes can also result in similar psychological benefits. Martinsen (1989) reported anxiety reduction following both aerobic and non-aerobic exercise programmes. He, (Martinsen, 1989) concluded that the reductions in anxiety were probably mediated via psychological mechanisms such as mastering and distraction, which is in agreeement with Sonstreom (1984), Bahrke & Morgan (1987) and Moses et al (1989).

Several of these possible mechanisms separately or together may explain the positive changes in elation and energy the present exercise group experienced following a 12 week programme of exercise.

5. 7. 5. Perception of Effort throughout the Exercise Programme

Table 12 and Figure 3 show mean ratings of perceived exertion throughout the exercise programme. Figure 3 shows that on the first few weeks of the exercise programme, subjects rated the sessions as being "hard". The ratings showed a downward trend as the exercise programme progressed with weeks 4 - 7 being rated as between "hard" and "somewhat hard". From weeks 8 - 12, the mean rating had levelled off to around 13, "somewhat Hard". This suggests that the subjects had perceived that the exercise had become easier. This decreased perception of effort during exercise may be linked with the concept of mastery, where exercisers have practised the activity sufficiently to allow them to master the task. Additionally, lactate levels during exercise can affect ratings of perceived exertion. A difference between trained and untrained individuals is the ability of the trained individual to undertake moderate exercise without raising blood lactate too much (Johansson, 1986). Borg, Ljunggren & Ceci (1985) concluded that a combination of lactate level and heart rate was a better indicator of perceived exertion than each of the single variables taken alone. The 12 week programme may have resulted in a reduction in lactate at a given intensity.

5. 7. 6. RPE - Comparison with other Training Studies

Several studies have have reported that RPE at the same sub-maximal workload is decreased after training (Ekblom & Goldbarg, 1971; Pandolf, Burse & Goldman, 1975). In the present study, exercise intensity, as shown by heart rate, did not vary significantly from week to week. However, RPE showed a progressive decrease. This is in agreement with these other studies (Ekblom et al, 1971; Pandolf et al, 1975) since RPE was significantly ($p < 0.001$) lower for a similar intensity in week 12 compared with week 1.

5. 7. 7 Summary

A 12 week exercise programme in women can significantly improve mood profile with particular emphasis on elation and energy. In addition, as training progressed, subjects began to perceive the exercise sessions to be less and less of an effort. This decreased perception of effort may be linked to subjects mastering the task (exercise programme).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6. 1. Conclusions

The exercise and control groups did not differ significantly in any of the variables at baseline.

The exercise group showed greater average improvements over the control group in the following variables :

Sum of Skinfolds
Estimated Percentage Body Fat
Steady State Heart
Estimated VO_2 Max
Abdominal Endurance
Hamstrings/Low back Flexibility
Elated-Depressed Mood factor
Energetic-Tired Mood factor

The exercise and control groups did not significantly differ in the changes to the following variables :
Body Weight
Blood Pressure
Resting Heart Rate
Total Cholesterol
Plasma Triglycerides
Composed-Anxious Mood Factor

Agreeable-Hostile Mood Factor
Confident-Unsure Mood Factor
Clearheaded-Confused Mood Factor
Diet

After the 12 week period, the exercise group had significantly higher VO_2 max (L/min), mean T scores for Elation/Depression and Energy/Tired mood factors and lower heart rates during sub-maximal exercise.

The aerobic component of the exercise programme has been effective in improving the efficiency of the cardiovascular system. A decreased sub-maximal heart rate implies an increased efficiency of the heart, that is, following training, myocardial oxygen consumption is less for a given submaximal heart rate. In addition, predicted VO_2 max showed a 17% increase suggesting that a programme of Popmobility or Tune-up sessions is an effective way of improving aerobic fitness in women.

The exercise group increased energy expenditure without significant change in the type of food consumed. The fact that the exercisers demonstrated greater average losses in body weight and fat over the controls, implies that the exercise programme must have created a small negative energy balance.

Although diastolic blood pressure showed a significant reduction from Test 1 to Test 2, the improvement cannot be linked to changes in aerobic fitness, since the control group showed a parallel improvement in diastolic blood pressure without any change in aerobic fitness.

Improvements in aerobic fitness did not result in changes in lipids. However, total cholesterol and triglycerides levels at baseline were within normal ranges, so large decreases would be unlikely.

Significant improvements were found in abdominal endurance and hamstrings/low back flexibility, which may result in improved in posture and reduced incidence of low back pain among participants.

The exercise programme resulted in improvements in elated-depressed and energetic-tired mood factors. Participants experienced increases in energy and elation, both of which are generally accepted psychological benefits of exercise. Additionally, subjects perceived the exercise to be less of an effort towards the end of the programme.

6. 2. Health Benefits from the Exercise Programme

6. 2. 1. Cardiovascular Benefits

The decreases in heart rate during sub-maximal exercise after 12 weeks is an indication of an improvement in the efficiency of the heart and skeletal muscle adaptations. A lower heart rate at a given sub-maximal workload following the exercise programme means that the heart does not have work as hard to supply the same amount of oxygen as before. The increase in predicted VO_2 max is also an indication of better efficiency of the heart and circulatory system in the supply and extraction of oxygen to the working muscles. An improvement in aerobic fitness allows the individual to perform everyday tasks with more ease.

6. 2. 2. Body Composition

Improvements in body composition are beneficial to health since excess fat is a risk factor in several diseases such as hypertension, coronary heart disease and diabetes. Although the exercise group was not initially obese, the body fat levels were towards the high end of "normal", so decreases in body fat are beneficial to the health of the subjects.

6. 2. 3. Abdominal Endurance and Flexibility

Low back pain is a very common ailment in the UK and is associated with poor trunk strength and flexibility. Exercisers showed significant increases in abdominal endurance and hamstrings /lower back flexibility. Improvements in these variables may result in improved posture and a decrease in the incidence and severity of low back pain.

6. 2. 4. Psychological Effects

Exercise is associated with improved mood, self-esteem and decreased depression and anxiety. The present exercise group showed significant improvements in elation/depression scores which agrees with previous findings. Additionally, the exercise programme resulted in an increase in mean T score for the energetic/tired factor. The present exercise programme has, therefore, contributed beneficially to the mental health of the participants.

6. 3. Limitations of Study

Assignment to groups was not random. Random assignment decreases the likelihood of groups being different at baseline. That is, a certain type of person may be predisposed to choose exercise, whereas others may choose not to exercise.

Analysis of Variance (ANOVA) may have been a more appropriate method of statistical analysis, since this method may show changes easier than the t-test method used.

The programme length was only 12 weeks, thus limiting greater adaptations in some of the variables, such as body fat.

Aerobic power was only predicted. This method is less valid than direct measurement of VO_2 max.

The method of assessing body composition only included upper body skinfold sites. Changes in lower body fat are more likely in female subjects.

The method of assessing food intake was not quantitative and did not include all foods consumed. The food frequency method used did not allow an estimate of energy intake to be assessed.

Local muscular endurance and flexibility were only confined to the trunk region of the body, thus ignoring the effects on the other muscle groups used in the sessions.

Only total cholesterol and plasma triglycerides were measured in the lipid analysis.This limited the comparison between the present study in women to the previous study on men, where HDL levels were assessed.

Lipids were not assessed in all subjects. This resulted in very small groups, thereby reducing statistical power.

6. 4. Recommendations for Future Research

Random assignment should be used, to reduce a selection bias.

In a study which measures change over time, ANOVA should be used for the statistical analysis.

The programme length should be longer to maximise changes in the variables.

If skinfold measures are used to assess body composition, lower body sites should be included, or another method such as hydrostatic weighing should be used to increase reliability.

Food intake should be assessed quantitatively by using a weighed food intake method for at least two five day periods during the exercise programme. This would allow an estimate of energy intake.

Other lipid parameters such as high density and low density lipoproteins should be assessed, since LDL and HDL have higher associations with coronary heart disease than total cholesterol and triglycerides. Therefore LDL and HDL are more important variables in health-related research.

Lipids should have been measured for all subjects. Larger samples would increase statistical power.

A study with both male and female participants following exactly the same exercise programme should be carried out to allow a better comparison of the responses of men and women to exercise.

REFERENCES

Abramson, P.A. & Trulson, M.F. (1062) Food Frequency Interview as an Epidemiological Tool
American Journal of Public Health 53: 1093-1101

Addison, R & Schultz, A. (1980) Trunk Strengths in Patients seeking Hospitalization for Chronic Low Back Disorders
Spine 5: 539-544

Adner, M.M., William, M.D. & Castelli, P. (1980) Elevated high density lipoprotein levels in marathon runners
Journal of the American Medical Association 243: 534-536

Allen, P.D. & Pandolf, K.B. (1977) Perceived exertion associated with breathing hyperoxiic mixtures during sub-maximal work
Medicine and Science in Sports 9: 122-127

Alter, M.J. (1988) Science of Stretching
Human Kinetics Publishers Ltd, Champaign, Illinois

American College of Sports Medicine (1978)
Position Statement on the Recommended Quantity and Quality of Exercise for Developing and maintaining Fitness in Healthy Adults.
Medicine and Science in Sports 10 : VII

American College of Sports Medicine Position Stand (1990) The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults
Medicine and Science in Sports and Exercise 22: 265-274

Andrews, G., MacMahon, S.W., Austin, A., Byrne, D.G. (1982) Hypertension: Comparison of drug and non-drug treatments
British Medical Journal 2. 84: 1253-1255.

Armstrong, G & Sutherland (1990) The Energy Cost of University Exercise Sessions
Unpublished Undergraduate Research Dissertation, University of Glasgow

Astrand, P.O.,; Rhyming, I. (1954) A Nomogram for Calculation of Aerobic Capacity (Physical Fitness)from Pulse rate during Submaximal Work
Journal of Applied Physiology 7 : 218-221

Astrand, P.O.; Rodahl, K. (1977) Textbook of Work Physiology, 2nd Edition McGraw Hill Book Co., New York

Astrand P.O., Rodahl, K (1986) <u>Textbook of Work Physiology</u>, 3rd Edition McGraw Hill Book Co., New York

Badenhop, D.T., Cleary, P.A., Schaal,S.F., Fox,E.L. & Bartels, R.L. (1983) Physiological adjustments to Higher and Lower Intensity Exercise in Elders <u>Medicine and Science in sports and Exercise</u> 15: 496-502

Baechle, T.R (1984) Women in Resistance Training. In Walsh,W.M. (Editor) . <u>Clinics in Sports Medicine</u> pp 791 - 808. Volume 13. Philadelphia, W.B Saunders Co.

Bahr, R., Ingnes, I., Vaage, O., Segersted, O.M., Newsholme, E.A. (1987) Effect of Duration of Exercise on Excess Postexercise O_2 Consumption: A Short Review <u>Acta Medica Scandinavica</u> 128 (Suppl 556): 99-106

Bahrke, M.S.;Morgan, W.P. (1978) Anxiety Reduction following Exercise and Meditation <u>Cognitive Therapy Research</u> 2: 41-54

Bale, P. & Davies, J. (1983) Effects of Menstruation and Contraceptive Pill on the Performance of Physical Education Students <u>British Journal of Sports Medicine</u> 17: 46-50

Ballantyne, D.; Clark, A.; Dyker, G.S.; Gillis, C.R. Hawthorne, V.M.; Henry, D.A.; Hole, D.S.; Murdock, R.M.; Semple, T. & Stewart, G.M. (1978) Prescribing Exercise for the Healthy; Assessment of Compliance and Effects on Plasma Lipids and Lipoproteins <u>Health Bulletin</u> 32: 169-176

Bassey, E.J. & Fentem, P.H. (1981) <u>Exercise - The Facts</u> Oxford. Oxford University Press.

Beck, A.T., Ward, C.H., Mendolsohn, M. & Erbaugh, H. (1961) An Inventory for Measuring Depression <u>Archives of General Psychiatry</u> 4: 561-571

Beral, V. (1976) Cardiorespiratory Disease Mortality Trends and Oral Contraceptive Use in Young Women <u>The Lancet</u> 1047-1052

Berger, B.G.; Owen, D.R. (1983) Mood Alteration with Swimming - Swimmers really do " Feel Better " <u>Psychosomatic Medicine</u> 45 :425-433

Berger, B.G.; Owen, D.R. (1988) Stress Reduction and Mood Enhancement in Four Exercise Modes : Swimming, Body Conditioning, Hatha Yoga and Fencing <u>Research Quarterly for Exercise and Sport</u> 59 : 148 - 159

Bielinski, r., Schultz, Y., Jequier, E. (1985) Energy Metabolism during the Post-exercise Recovery in Man <u>American Journal of Clinical Nutrition</u> 42: 69-82

Birk, T.J. & Birk, C.A. (1987) Use of Perceived Exertion for Exercise Prescription
Sports Medicine 4: 1-8

Bjornthorp, P.A. (1989) Sex Differences in the Regulation of Energy Balance with Exercise
American Journal of Clinical Nutrition 49 :958-961

Blair, S.N., Ellsworth, N.M., Haskell, W.L., Stern, W.P., Farquar, J.W. (1981) Comparison of Nutrient Intake in Middle-aged Men and Women Runners and Controls
Medicine and Science in Sports and Exercise 13: 310-315

Blair, S.N.; Goodyear, N.M.; Wynne, K.L.; Saunders, R.P. (1984) Comparison of Dietary and Smoking habit changes in Physical Fitness Improvers and Nonimprovers
Preventive Medicine 13 :411-420

Blair, S.N.; Goodyear, N.N., Gibbons, L.W., Cooper, K.H. (1984) Physical Fitness and Incidence of Hypertension in Healthy Normotensive Men and Women
Journal of the American Medical Association 252 : 487-490

Blomqvist, C.G. & Saltin, B.(1983) Cardiovascular Adaptatiions to Physical Training
Annual Review of Physiology 45: 169-189

Blumenthal, J.A.; Williams, R.S., Needels T.L., Wallace, A.G. (1982) Psychological Changes accompany Aerobic Exercise in Healthy Middle-aged Adults
Psychosomatic Medicine 44 : 529-536

Blumenthal, J.A., Sanders, W., Williams, R.B. & Wallace, A.G. (1980) Effects of Exercise on the Type-A (Coronary-Prone) Behavior Pattern
Psychosomatic Medicine 42: 289-296

Blumenthal, J.A.; Emery, C.F.; Walsh, M.A.; Cox, D.A.; Kuhn, C.M.; Williams, R.B.; Williams, R.S. (1988) Exercise Training in Healthy Type-A Middle Aged Men: Effects on Behavioral and Cardiovascular Responses
Psychosomatic Medicine 50 :418-433

Bonnano, J.A. & Lies, J.E. (1974) Effects of Physical Training on Coronary Risk Factors
American Journal of Cardiology 33: 760 - 764

Borg, G. (1970) Perceived Exertion as an Indicator of Somatic Stress
Scandinavian Journal of Rehabilitation Medicine 2: 92-98

Borg, G.A.V.(1982) Psychophysical Bases of Perceived Exertion
Medicine and Science in Sport and Exercise 14: 377-381

Borg, G., Ljunggren, G. & Ceci, R. (1985) The Increase of Perceived Exertion, Aches and Pains in the Legs, Heart Rate and Blood Lactate during Exercise on a Bicycle Ergometer
European Journal of Applied Physiology 54: 343-349

Bradley, D.D.; Wingerd, J.; Pettiti, D.; Krauss, P.; Damcharan, S. (1978) Serum High Density Lipoprotein Cholesterol in Women using Oral Contraceptives, Estrogens and Progestins
New England Journal of Medicine 199 :17-20

Brehm, B.A. & Gutin, B. (1986) Recovery Expenditure for Steady State Exercise in Runners and Non-runners. Medicine and Science in Sports and Exercise 18 : 205-210

Brewer, V. & Hinson, M. (1978) Relationship of Pregnancy to Lateral Knee Stability
Medicine and Science in Sports 10: 39

Exercise and the Heart (1990)
Report of the British Heart Foundation Working Party

Brodie, D.A. (1988) Tecniques of Measurement of Body Composition. Parts I & II
Sports Medicine 5: 11-40 ; 74-98

Brooks, G.A., & Fahey, T.D. (1984) Exercise Physiology : Human Bioenergetics and its Applications J. Wiley & Sons, New York

Brooks-Gunn, J.; Gargiulo, J.M.; Warren, M.P. (1986) Effect of Cycle Phase on the Performance of Adolescent Swimmers
Physician and Sportmedicine 14 :182-192

Brotherston, K.G (Ed) (1985) The Scottish Epidemic 2nd Edn. Scottish Action on Smoking and Health

Brown, B.S. & Van Huss (1973) Exercise and Rat Brain Catecholamines
Journal of Applied Physiology 34: 664 - 669

Brownell, K.D.; Bachorik, P.S.; Ayerle, R.S. (1982) Changes in Plasma Lipid and Lipoprotein Levels in Men and Women after a Programme of Moderate Exercise
Circulation 65 :477-483

Bryant, S. (1984) Flexibility and Stretching
Physician and Sportsmedicine 12: 171

Buffone, G.W. (1984) Running and Depression. In Sachs,M.L & Buffone (Eds) Running as Therapy. An Integrated Approach. Lincoln, Univrsity of Nebraska Press.

Burke, E.S. (1986) Perceived Exertion: Subjectivity and Objectivity in Work Intensity Assessment : In Borg, G. Ottoson (eds) The Perception of Effort in Physical Work London. MacMillan Press.

Bush, T.L., Fried, L.P., Barratt-Connor, E. (1988) Cholesterol, Lipoproteins and Coronary Heart Disease in Women
Clinical Chemistry 34(8B): B60-B70

Buxtorf, J.C.; Baudet, M.F.; Martin, C.; Richard, J.L. (1988) Seasonal Variations of Serum Lipids and Apoproteins
Annals of Nutrition and Metabolism 32 :68-74

Cade, R.; Mars, D.; Wagemaker, H.; Zauner, C.; Privette, M.; Cade, M.; Peterson, J.; Hood-Lewis, D. (1984) Effect of Aerobic Exercise Training on Patients with Systemic Arterial Hypertension
American Journal of Medicine 77 :785-790

Canadian Standardized tests of fitness (CSTF) Operations Manual (3rd edition). Canada: Minister of State, Fitness and Amateur Sport

Capen, E.K. (1950) The Effect of Systematic Weight Training on Power, Strength and EnduranceResearch Quarterly 21: 38-93

Carr, D.B, Bullen, B.A., Skrinar, G.S., Arnold, M.A., Rosenblatt, M, Beitins, I.Z., Martin, J.B., McArthur, J.W. (1981) Physical Conditioning Facilitates the Exercise-induced Secretion of beta-endorphin and beta-lipotropin in Women
New england Journal of Medicine 305: 560-563

Casperson, C.J.; Powell, K.E.; Christenson, G.M. (1985)
Physical Activity, Exercise and Physical Fitness: Definitions and Distinctions for Health Related Research
Public Health Reports 100 :126-131

Castelli, W.P., Gordon, T. & Doyle, J. (1977) HDL-Cholesterol and other Lipids in Coronary Heart Disease. The Cooperative Lipoprotein Phenotyping Study
Circulation 55: 767-787

Cearly, M.L.; Moffatt, R.J.; Knutzen, K.M. (1984) The Effects of two- and three- times per week Aerobic Dance Programs on Maximal Oxygen Uptake
Research Quarterly Exercise and Sport 55 :172-174

Chaffin, D.B. (1974) Human Strength Capacity and Low Back Pain
Journal of Occupational Medicine 16: 248-254

Christie, M.J. & Chester, T.C. (1982) Physical Dependence on Physiologically Released Endogenous Opioids
Life Sciences 30: 1173 - 1177

Clausen, J.P. (1977) Effect of Physical Training on Cardiovascular Adjustments to Exercise in Man
Physiological Reviews 57 : 779-810

Colt. E.D.W., Wardlaw, S.L. & Franz, A.G. (1981) The Effect of Running on Plasma Beta-Endorphin
Life Sciences 28: 1637 - 1640

Consensus Conference (1985) Lowering Blood Cholesterol to Prevent Heart Disease
Journal of the American Medical Association 253 : 2080-2086

Corbin, C.B. & Noble, L. (1980) Flexibility : A Major Component of Physical Fitness
Journal of Physical Education and Recreation. June , 1980

Cornelius, W.L. (1983) Stretch Evoked EMG Activity by Isometric Contraction and Submaximal Concentric Contraction
Athletic Training 18: 106-109

Cornelius, W.L. (1990) Benefits from Flexibility Exercise
National Strength and Conditioning Journal 12 : 61 - 64

Craig, I.H.; Brotherhood, J.; Hill, G.; D'Andrea, R. (1981)
Effects of a 12 Week Exercise Programme on Serum Lipid and Apolipoprotein Levels in Men and Women.
Circulation (Suppl IV) :81

Cunningham, D.A., MacCrimmon, D. & Vlach, L.F. (1979) Cardiovascular Response to Interval and Continuous Training in Women
European Journal of Applied Physiology 41: 187-197

Dagget, A.; Davies, B.; Boobis, L. (1983) Physiological and Biochemical Responses to Exercise following Oral Contraceptive use (Abstract)
Medicine and Science in Sports and Exercise 15: 174

Darga, L.L.; Lucas, C.P.; Spafford, T.R., Schork, M.A.; Illis, W.R.; Holden, N. (1989) Endurance Training in Middle-aged Male Physicians
Physician and Sportsmedicine 17: 85-101

De Bruyn-Prevost, P.; Masset, C.; Stubols, X. (1984) Physiological Response from 18-25 years Women to Aerobic and Anaerobic Physical Fitness Tests at Different Periods during the Menstrual Cycle
Journal of Sports Medicine 24 :144-148

De Coverley Veale, D.M.W. (1987) Exercise Dependence
British Journal of Addiction 82: 735-740

Dempsey, J.A., Hanson, P. & Henderson, K.(1984) Exercise-induced Arterial Hypoxemia in Healthy Humans at Sea Level
Journal of Physiology 355: 161 - 169

de Vries, H.A. (1962) Evaluation of Static Stretching for Improvement in Flexibility
Research Quarterly 32 : 222 - 239

de Vries, H.A. (1966) Quantitative Electromyographic Investigation of the Spasm Theory of Muscle Pain
American Journal of Physical Medicine 45 : 119 - 134

de Vries, H.A. & Adams, G.M. (1972) Comparison of Exercise Responses on Old and Young Men
Journal of Gereontology 27 : 344 - 348

de Vries, H.A. (1974) Physiology of Exercise for Physical Education and Athletics, 2nd Edn. Dubuque, Wm. Brown

de Vries, H.A. (1981) Tranquilizer Effect of Exercise
Psysician and Sportsmedicine 9: 48-49

Dibrezzor, R.; Fort, I.L.; Brown, B. (1988) Dynamic Strength and Work Variations during Three Stages of the Menstrual Cycle
Journal of Orthopaedic and Sports Physical Therapy 10 :113-116

Dishman, R.K. (1984) Motivation and Exercise Adherence : In Silva J.M. & Weinberg R.S. (eds) - Psychological Foundations of Sport. Human Kinetics Publ.

Doolittle, T.L.; Engebretsen, J. (1972) Performance Variations during the Menstrual Cycle
Journal of Sports Medicine 12 :54-58

Doskin, V.A.; Kozeeva, T.V.; Lisitskaya, T.S.;Shokina, E.V. (1980) Changes in Working Capacity of Female Athletes in Different Phases of the Menstrual Cycle
Fiziologiya Cheloveka 5: 221-227

Doyne,E.J., Chambless, D.L., Beutler, L.E. (1983) Aerobic Exercise as a Treatment for Depression in Women
Behavioral Therapy 14: 434-440

Duncan, J.J.; Farr, J.E.; Upton, J.S.; Hagen, R.D.; Oglesby, M.E.; Blair, S.N. (1985) The Effects of Aerobic Exercise in Plasma Catecholamines and Blood Pressure in Patients with Mild Hypertension
Journal of the American Medical Association 254 :2606-2613

Durnin, J.V.G.A.; Womersley, J .(1974) Body fat Assessment from Total Body Density and its Estimation from Skinfold Thickness Measurements on 481 Men and Women from 17-74 years
British Journal of Nutrition 32 :77-97

Durstine, J.L.; Pate, R.R. & Sparling, P.B. (1987) Lipid, Lipoprotein and Iron Status of Elite Female Distance Runners
International Journal Of Sport Medicine 8(Suppl): 119-123

Durstine , J.L. & Pate, R.R. (1988) Cardio-respiratory Responses to Acute Exercise Chapter 7, pp 48 - 54 In American College of Sports Medicine, Resourse Manual for Exercise testing and Prescription. Philadelphia, Lea & Febiger.

Dyer, K.F. (1982) Challenging the men: The social biology of female sporting achievement.
St. Lucia: University od Queensland Press

Dyer, J.B.; Crouch, J.G. (1988) Effects of Running and other Activities on Moods
Perceptual and Motor Skills 67 :43-50

Edwards, M.A.(1974) Effects of Training at Predetermined Heart Rate Levels for Sedentary College Women
Medicine and Science in Sports 6 :14-19

Ehansi, A.A. (1987) Cardiovascular Adaptations to exercise Training in the Elderly
Federation of American Societies for Experimental Biology 46: 1840-1843

Ekblom, B., Astrand, P.O., Saltin, B., Stenberg, J., Willstrom, B. (1968) Effect of Training on Ciculatory Response to Exercise
Journal of Applied Physiology 24 : 24 : 518 - 528

Ekbolm, B.; Goldbarg, A.N. (1971) The influence of Training and other Factors on the Subjective Rating of Perceived Exertion
Acta Physiologica Scandinavia 24 :399-406

Ekblom,B., Kilbom, A. & Soltysiak, J. (1973) Physiacl Training, Bradycardia, Autonomic Nervous system
Scandinavian Journal of Clinical Investigation 32: 251-256

Epstein, L.H. & Wing, R.R. (1980) Aerobic Exercise and Weight
Addictive Behavior 5: 371-388

Eston, R.G. (1984) The Regular Menstrual Cycle and Athletic Performance
Sports Medicine 1 :431-445

Eston, R.G. & Burke, E.J. (1984) Effects of the Menstrual Cycle on Selected Responses to Short Constant Load Exercise
Journal of Sports Sciences 2: 145-153

Etnyre, B.R., Lee, E.J. (1987) Comments on Proprioceptive Neuromuscular Facilitation Stretching Techniques
Research Quarterly for Exercise and Sports 58: 184-188

Etnyre, B.R. & Lee, E.J. (1988) Chronic and Acute Flexibility of Men and Women using three different Stretching Techniques
Reaserch Quarterly for Exercise and Sports 59: 222-228

European Atherosclerosis Society (1987) Strategies for the Prevention of Coronary Heart Disease: A Policy Statement of the European Atherosclerosis Society
European Heart Journal 8: 77-88

Eynde, B.V. & Ostyn, M. (1986) Rate of Perceived Exertion and its Relationship with Cardiorespiratory Response to Submaximal amd Maximal Muscular Exercise. Chapter 27, pp 327-335. In Borg, G. & Ottoson, D (Eds) The Perception of Exertion in Physical Work. London : MacMillan Press Ltd.

Fagard, R. (1985) Habitual Physical Activity, Trainingand Blood Pressure in Normo- and Hypertension
International Journal of Sports Medicine 6:57-67

Farfan, H.F. (1978) The Biomechanical Advantage of Lordosis and Hip Extension for Upright Activity
Spine 3: 336-342

Faria, I (1970) Cardiovascular Responses to Exercise as influenced by Training at Various Intensities
Research Quarterly 41: 44-49

Farrell, P.A.; Barboriak, J. (1980) The Time Course of Alterations in Plasma Lipid and Lipoprotein Concentrations during eight weeks of Endurance Training
Atherosclerosis 37 :231-238

Farrell, P.A., Gates, W.K., Maksud, M.G. & Morgan, W.P. (1982) Increases in Plasma Beta-endorphin/lipotropin Immunoreactivity after Treadmill Running in Humans
Journal of Applied Physiology 52: 1245-1249

Fleck, S.J. & Kraemer, W.J. (1987) Designing resistance training programs
Champaign. Human Kinetics Books

Flint, M.M. (1957) Effect of Increasing Back and Abdominal Muscle Strength on Low Back Pain
Research Quarterly 29 :160-171

Flint,M.M., Drinkwater, B.L. & Horvath, S.M.(1974) Effects of Training on Women's Response to Submaximal Exercise
Medicine and Science in Sports 6: 89-94

Folkins, C.H & Sime, W.E. (1981) Physical Fitness Training and Mental Health
American Psychologist 4: 373-389

Foster, C. (1975) Physiological Requirements of Aerobic Dancing
Research Quarterly 46: 120-122

Fox, E.L. (1979) Sports Physiology. Philadelphia: W.B Saunders Co.

Fox, E.L. (1980) Physiological Effects of Training
Encyclopaedia of Physical Education, Fitness & Sports 2:31-51

Fox, E.L. & Mathews, (1981) The Physiological Basis of Physical Education and Athletics (3rd Edn) Iowa, Wm. Brown Publ.

Fox, E.L., Bowers, R.W. & Foss, M.L. (1989) The Physiological Basis of Physical Education and Athletics (4th Edn) Iowa, Wm. Brown Publ.

Freedman-Akabas, S., Colt, E., Kissilef, H.R., Pi-Sunyer, F.X. (1985) Lack of Sustained Increase in VO_2 following Exercise in Fit and Unfit Subjects
American Journal of Clinical Nutrition 41: 545-549

Frey, M.A.B.; Doerr, B.M.; Laubach, L.L.; Mann, B.L.; Glueck, C.J. (1982) Exercise does not Change High-Density Lipoprotein Cholesterol after Ten Weeks of Training
Metabolism 31 :1142-1145

Froehlich, E.D., Gifford, R.W., Dallas Hall, W. (1987) Hypertensive Cardiovascular disease.
Journal of the American College of Cardiology 10: 57A-59A.

Gaesser, G.A.; Rich, R.G. (1984) Effects of High and Low Intensity Exercise Training in Aerobic Capacity and Blood Lipids
Medicine and Science in Sports and Exercise 16 :269-274

Gambert, S.R., Hagen, T.C., Garthwaite, T.L., Duthrie, E.H. & McCarty, D.J. (1981) Exercise and Endogenous Opioids
New England Journal of Medicine 305: 1590 - 1592

Garrick, J.G.; Requa, R.K. (1988) Aerobic Dance - a Review
Sports Medicine 6 :169-179

Gettman, L.R., Pollock, M.L., Dustine, J.L., Ward, A., Ayres, J. & Linnerund, A.C. (1977) Physiological Reponse of Men to 1, 3 and 5 days per week Training Programs
Research Quarterly 47: 638-646

Gibbons, L.W.; Cooper, K.H.; Blair, S.N.; Smith, M. (1983) Association between Coronary Disease Risk Factors and Physical Fitness in Healthy Adult Women
Circulation 67 :977-983

Gikk, K, Price, V.A., Friedman, (1986) Reduction in Type-A Behaviour in Healthy, Middle-aged American Military Officers
American Heart Journal,110: 503 - 514

Gilders, R.M.; Voner, C.; Dudley, G.A. (1989) Endurance Training and Blood Pressure in Normotensive and Hypertensive Adults
Medicine and Science in Sports and Exercise 21 :629-636

Gyntelberg, F, Brennan, R., Hollosky, J, Schonfield, G, Rennie, M. & Weidman, S. (1977) Plasma Triglycerides Lowering despite Increased Food Intake in Patients with Type IV Hyperlipoproteinaemia
American Journal of Clinical Nutrition 30: 716 - 720

Goldberg, L.; Elliot, D.L. (1987) The Effect of Exercise on Lipid Metabloism in Men and Women
Sports Medicine 4: 307-321

Golub, L.G., Christaldi, J. (1957) Reducing Dysmennorrhoea in Young Adolescents
Journal of health, Physical education and Recreation 28: 24-25, 59

Gordon, T.; Castelli, W.P.; Hjortland, M.C. (1977) High Density Lipoproteins as a Protective Factor against Coronary Heart Disease
American Journal of Medicine 62: 707-714

Grant, S. (1989) The effects of a university fitness programme on health related variables in previously sedentary males.
Unpublished M.Sc. Thesis, University of Glasgow

Griest, J.H.; Klein, M.H.; Eischens, R.R. Faris, J.; Gurman, A.S. & Morgan, W.P. Running as a Treatment for Depression
Comprehensive Psychiatry 20: 41-54

Hagberg, J.M., Goldring, D., Ehansi, A.A., Heath, G.W. & Hernandez, A. (1983) Effect of Exercise Training on the Blood Pressure and Haemodynamic Features of Hypertensive Adolescents
American Journal of Cardiology 52: 763-768

Hagberg, J.M. (1990) Exercise, Fitness and Hypertension. In Bouchard et al (Editors) Exercise, Fitness and Health. A Consensus of Current Knowledge. Champaign, Illinois. Human Kinetics Publishers.

Hammond, H.K. & Froelicher, V.F.(1984) Exercise Testing for Cardoirespiratory Fitness
Sports Medicine 1 : 243-239

Hanson, J.S. & Nedde, W.H.(1974) Long Term Physical Training Effect on Sedentary Females
Journal of applied Physiology 37: 112-116

Harber, V.J. & Sutton, J.R. (1984) Endorphins and Exercise
Sports Medicine 1: 154-171

Hardman, A.E.; Hudson, A. (1991) Exercise and Lipoprotein Metabolism in Women
Journal of Human Nutrition and Dietetics 4: 57-62

Hardy, L & Jones, D. (1985) Dynamic Flexibilty and Proprioceptor Neuromuscular Facilitation
Research quarterly for Exercise and Sports 57: 150-153

Hart, J.T.(1986) Taking the Pressure out of High Blood Pressure
Self Health 11: 20-21

Hartung, G.H., Foreylt, J.P., Mitchell, R.E. Vlasek, I & Gotto, A.M. (1980) Relation of Diet to High Density Lipoprotein Cholesterol in Middle-aged Marathon Runners, Joggers and Inactive Men
New England Journal of Medicine 302: 357-361

Haskell, W.L. (1984) The influence of Exercise on the Concentrations of Triglycerides and Cholesterol in Human Plasma pp 205 - 244 In Terjung, R.L. (Editor) Exercise and Sports science Reviews. Lexington. The Collarmore Press

Haskell, W.L.(1983) The Influence of Exercise Training on Plasma Lipids and Lipoproteins in Health and Disease
Acta Medica Scandinavia Supplement 711 :25-37

Haskell, W.L.; Taylor, H.L.; Wood, P.D.; Schrott, H. (1980) Strenuous Physical Activity, Treadmill Exercise Test Performance and Plasma High-density Lipoprotein Cholesterol. The Lipids Research Clinics Program Prevelence Study
Circulation 62(suppl. IV) :53-61

Health Education Department and Greater Glasgow Health Board
Healthy heart guide - give your heart a chance

Hegsted, D.M.; Nicolosi, R.J. (1987) Individual Variations in Serum Cholesterol Levels
Proceedings of the National Academy of Science, U.S.A

Hemer, H.A.; de Bourges, V.V.; Ayala, J.J.; Brito, G.; Diaz-Sanchez, V.; GarzaFlores, J. (1985) Variations in Serum Lipids and Lipoproteins throughout the Menstrual Cycle
Fertility and Sterility

Heyward. V.H.(1984) Designs for Fitness: A guide to Physical fitness Appraisal and Exercise Prescription. Minneapolis. Burgess Publishing Co.

Hickson, R.C.; Rosenkoetter, M.A. (1981) Reduced Training Frequencies and Maintenance of Increased Aerobic Power
Medicine and Science in Sports and Exercise 13 :13-16

Hickson, R.C. , Hagberg, J.M., Erhansi, A.A. & Hollosky, J.O. (1981) Time course of Loss of the Adaptive Responses of Aerobic Power and Heart Rate to Training
Medicine and Science in Sports and Exercise 13: 17-20

Hickson, R.C., Foster, C., Pollock, M.L., Galassi, T.M. & Rich, S. (1985) Reduced Training Intensities and the Loss of Aerobic Power, Endurance and Cardiac Growth
Journal of Applied Physiology 58: 492-499

Hill, J.O.; Thiel, J.; Heller, P.A.: Markon, C; Fletcher, G.; DiGirolamo, M. (1989) Differnces in the Effects of Aerobic Exercise Training on Blood Lipids in Men and Women
American Journal of Cardiology 63: 254-256

Hilyer, J.C., Brown, K.C., Sirles, A.T. & Peoples, L (1990) A Flexibility Intervention to Reduce the Incidence and Severity of Joint Injuries among Municipal Firefighters
Journal of Occupational Medicine 32: 631-637

Hollosky, J.O. (1973) Biochemical Adaptations to Exercise : Aerobic Metabolism
In Wilmore, J.H. (Ed) Exercise and Sports Sciences Reviews 1:46-58 New York Academic Press.

Houston, M.C. (1989) New Insights and New Approaches for the Treatment of Essential Hypertension : Selection of Therapy Based on Coronary Heart Disease Risk Factor Analysis, Haemodynamic Profiles, Quality of Life and Subsets of Hypertension
American Heart Journal 117: 911-951

Hurley, B.F. (1989) Effects of Resistance Training on Lipoprotein-Lipid Profiles: a Comparison to Aerobic Exercise Training
Medicine and Science in Sport and Exercise 21 :689-693

Hyner,G.C., Marconyak, M, Black, D.R.& Melby, C.L. (1986) Assessment of Body Composition by Novice Practitioners after a Short, Intensive Training Session
Journal of Sports Medicine 26: 421-426

Ingjer, F (1978) Effects of Endurance Training on Muscle Fibre ATP-ase Activity, Capillary Supply and Mitochondrail Content in Man
Journal of Physiology 294: 419-432

Ingjer, F. & Brodal, P. (1978) Capillary Supply of Skelatal Muscle Fibres in Untrained and Endurance Trained Women
European Journal of Applied Physiology 38: 291-299

Jackson, A. & Baker, A. (1986) The Relationship of Sit and Reach Test to Criterion Measures of Hamstrings and Back Flexibility in Young Females
Research Quarterly for Exercise and Sports 57: 183-186

Jackson, A. & Langford, N.J. (1989) The Criterion Related Validity of the Sit and Reach Test: Replication and Extension of Previous Findings
Research Quarterly for Excercise and Sports 60: 384-387

Jacobs, D.R.; Mebane, I.L.; Bangdiwala, S.I.; Criqui, M.H.; Tyroler, H.A. (1990) High Density Lipoprotein Cholesterol as a Predictor of Cardiovascular Disease Mortality in Men and Women: the Follow-up Study if the Lipids Research Clinics Prevalence Study
American Journal of Epidemiology 131 :32-47

Janal, M.N., Colt, E.W.D., Clark, W.C. & Glusman, M (1984) Pain Sensitivity, Mood and plasma Endocrine Levels in Man following Long Distance Running- Use of Naloxone
Pain 19: 13-25

Jennings, G.; Nelson, L. & Nestel, P (1986) The Effects of Changes in Physical Activity on Major Cardiovascular Risk Factors, Hemodynamics, Sympathetic Function and Glucose Utilisation in Man : A Controlled Study of Four Levels of Activity
Circulation 73: 30-40

Johansson, S. (1985) Perceived Exertion, Heart Rate and Blood Lactate during prolonged Exercise on a Bicycle Ergometer In Borg, G & Ottoson, D (Eds) The Percption of Exertion in Physical Work. London. MacMillan Press.

Johansson, S., Bondjers, G., Fagar, Wedel, H., Tsipoginni, A., Olofsson, S.V., Vedin, A., Wiklund, O. & Wilhelmsson, C (1988) Serum Lipids and Apolipoprotein Levels in Women with Acute Myocardial Infarction
Arteriosclerosis 8: 742 - 749

Johnson, S,; Berg, K.; Latin, R. (1984) The Effects of Training Frequency of Aerobic Dance on Oxygen Uptake, body composition and personality
Journal of Sports Medicine 24 :290-298

Joseph, J.J.; Bena, L.L.(1977) Cholesterol Reduction - a Long Term Intense Exercise Programme
Journal of Sports Medicine 17 :163-168

Kannel, W.B., Doyle, J., Ostfield, A.M., Jenkins, D., Kuller, L.,Podell, R.N. & Stamler, J. (1984) Optimal Resourses for Primary Prevention
Circulation 70 :155A - 205A

Kannel, W.B.; Wison, P.; Blair, S.N. (1985) Epidemiological Assessment of the Role of Physical Activity and Fitness in the Development of Cardiovascular Disease
American Heart Journal 109 :876-885

Kannel, W.B.(1987) Metabolic Risk Factors of Coronary Heart Disease in Women: Prespective from the Framington Study
American Heart Journal 114 :413-419

Kaplan, N.M. (1984) Therapy of Mild Hypertension : An Overview
American Journal of Cardiology 53: 2A-8A.

Karvonen, M. ; Kentala, K; Mustala, O. (1957) The Effects of Training on Heart Rate: a Longitudinal Study
Finland Journal of Experimental Medicine 35 :307-315

Katch, F.I., Michael, E.D. & Jones, E.M. (1969) Effects of Physical Training on the Body Composition and Diet of Females
Research Quarterly 40: 99-104

Katch, F.I. & McArdle W.L. (1988) Nutrition, Weight Control and Exercise (2nd Edition)

Kilbom A. (1971) Physical training in Women Scandinavian Journal of Clinical and Laboratory Investigation 28 (Suppl 119) : 7-34

King, A.C.; Taylor, A.B.; Haskell, W.L.; DeBusk, R.F. (1989) Influence of Regular Aerobic Exercise on Psychological Health: a Randomised, Controlled Trial of Healthy, Middle-aged Adults Health Psycholgy 8: 305-324

Kippers, V. & Parker, A. (1987) Toe Touch Test: A Measure of its Validity Physical Therapy 67: 1680-1684

Kiyonaga, a.; Arakawa, K.; Tanaka, H. & Shindo, M. (1985) Blood Pressure and Hormonal Responses to Aerobic Exercise Hypertension 7: 125-131

Klein, M.H.; Griest, J.H.; Gurman, A.S.; Neimeyer, R.A.; Lesser,D.P.; Bushell,N.J. & Smith, N.E. (1985) A Comparative Outcome Study of Group Psychotherapy versus Exercise Treatments for Depression International Journal of mental Health 13: 148-177

Knortz,S. (1985) Flexibility techniques National Strength Coaches Association Journal 7: 50-53

Knutten, H.G. (1970) Oxygen Debt after Submaximal Exercise Journal of Applied Physiology 29: 651-657

Kraus, H., Raab, W. & White, P.D. (1961) Hypokinetic Disease. Springfield, Illinois. Charles C.Thomas Publ.

Krotkiewski, M; Mandroukas, K.; Sjostrom, M; Sullivan, L.; Wetterqvist, H. & Bjorntorp, P. (1979) Effects of Long Term Physical Training on Body Fat, Metabolism and Blood Pressure in Obesity Metabolism 28: 650-658

Kukkonin, K., Raurama, R., Voutilainen, E. & Lansimies, E. (1982) Physical Training of Middle-aged Men with Borderline Hypertension Annals of Clinical Research 14 (suppl 34): 139-145

Lamb, D.R. (1978) Physiology of exercise. Responses and adaptations. New York: MacMillan Publishing Co. Ltd.

Laubach, L.L. (1976) Comparative Muscular Strength of Men and Women: A Review of Literature Aviation, Space and Environmental Medicine 47: 534-542

Leaf, D.A.; Parker, D.L. (1988) Body Weight or Percent Body Fat? Assessing Coronary Artery Disease Risk based in Plasma Lipid Profiles
Annales of Sports Medicine 4 : 143-144

Ledwidge, B. (1980) Run for your Mind : Aerobic Exercise as a Means of Alleviating Anxiety and Depression
Canadian Journal of Behavioral Sciences 12: 126-140

Lehtonen, A. & Viikari, J. (1878) Serum Triglycerides and Cholesterol and Serum HDL-cholesterol in Highly Physically Active Men
Acta Medica Scandinavica 204: 111-114

Lenskyj, H. (1988) Women, Sport and Physical Activity: Research and Bibliography. Canada: Minister of state, fitness and amateur sport.

Lew, E.A. (1973) High Blood Pressure, other Risk Factors and Longevity. The Insurance Viewpoint
American Journal of Medicine 55; 281-294

Lewis, S.; Haskell, W.L.; Wood, P.D.; Manoogian, N; Bailey, J.E. & Pereira, M (1976)
American Journal of Clinical Nutrition 29: 151-

Linder, C.W., Durant, R.H. & Mahoney, O.M. (1983) The Effect of Physical Conditioning on Serum Lipids and Lipoproteins in wWite Male Adolescents
Medicine and Science in Sports and Exercise 15: 233-236

Lokey, E.A.; Tran, Z.V. (1989) Effects of Exercise Training on Serum Lipid and Lipoprotein Concentrations in Women: a Meta-analysis

Lorr, M. & McNair, D.M. (1988) Profile of Mood states Bi Polar Form) Manual. San Diego : Educational and Industrial Testing Service

Lucas, R.C. & Koslow, R. (1984) Comparitive Study of Static, Dynamic and Proprioceptor Neuromuscular Facilitation Stretching Techniques on Flexibility
Perceptual and Motor Skills 58: 615-618

Luft, F. C. (1989) Hypertension and Exercise
Advances in Sports Medicine and Fitness 2 :119-135

Maehlum, S., Grandmontagne, M., Newsholme, E.A., Sejersted, O.M. (1986) Magnitude and Duration of Excess Postexercise Oxygen Comsumption in Healthy Young Subjects
Metabolism 35: 425-429

Mann, G., Garrett, H., Murray, H., Billings, F., Shute, E., Schwarten, S.E. (1969) Exercise to prevent Coronary Heart Disease. An Experimental Study of the Effects of Training on Risk Factors for Coronary Disease in Men
American Journal of Medicine 46: 12-27

Marcinick, E.J., Hodgson, J.A., Mittleman, K., O'Brien, J.J. (1985) Aerobic/calisthenic and Aerobic/circuit Weight Training Programmes for Navy Men: A comparitive study
Medicine and Science in Sports and Exercise 17: 482-487

Markoff, R.A., Ryan, P & Young, T. (1982) Endorphins and Mood Changes in Long Distance Running
Medicine and Science in Sports and Exercise 14: 11-15

Martin, R.P.; Haskell, W.L. & Wood, P.D. (1977) Blood Chemistry and Lipid Profiles of Elite Distance Runners
Annals of the New York Accadamy of Science 301: 346-360

Martinsen, E.W., Medhus, A. & Sandvik, L. (1985) Effects of Aerobic Exercise on Depression. A Controlled Study.
British Medical Journal 291: 100

Martinsen, E.W. Hoffort, A. & Solberg, O. (1989) Comparing Aerobic and non-aerobic forms of Exercise in the Treatment of Clinical Depression; A Randomised Trial
Comprehensive Psychoatry 30: 324-331

Martinsen, E.W. (1990) Benefits of Exercise for the Treatment of Depression
Sports Medicine 9: 323-329

Massicotte, D.R.; Avon, G.; Corriveau, G. (1979) Comparative Effects of Aerobic Training on Men and Women
Journal of Sports Medicine 19 :23-32

Mathews, D.K. & Fox, E.L. (1981) The Physiological basis of Physical Education and Athletics (2nd Edition). W.B. Saunders Co., Philadelphia.

Matthews, K.A.; Haynes, S.G. (1986) Type-A Behavior Patterns and Coronary Disease Risk. Update and Critical Evaluation
American Journal of Epidemiology 123 :923-960

Mattson, L.A.; Silverstolpe, G.; Samsloe, G. (1984) Lipid Composition of Serum Lipoproteins in Relation to Gonadal Hormones during the Normal Menstrual Cycle
European Journal of Obstetrics, Gynocology and Reproductive Biology 17 :327-335

McArdle, W.D., Zwiren, L & Magel, J.R. (1969) Validity of the Post-exercise Heart Rate as a Means of Estimating Heart Rate during Work of Varying Intensities
Research Quarterly 40: 523-528

McArdle, W.D., Katch, F.I & Katch, V.L. (1986)
Exercise Physiology, Energy, Nutrition & Human Performance Philadelphia Lea & febiger.

McCann, I.L.; Holmes, D.S. (1984) Influence of Aerobic Exercise on Depression
Journal of Personality and Social Psychology 46 :1142-1147

McCord, P.; Nichols, J.; Patterson, P. (1989) The Effect of Low Impact Dance Training on Aerobic Capacity, Submaximal Heart Rates and Body Composition in College Aged Females
Journal of Sports Medicine 29 :184-188

McCunney, R,J.(1987) Fitness, Heart Disease and High Density Lipoproteins: a Look at the Relationships
Physician and Sports Medicine 15 :67-79

MacDougall, J.D. Ward, G.R., Sale, D.G. & Sutton, J.R. (1977) Biochemical Adaptation of Human Skeletal Muscle to Heavy Resistance Training and Immobilisation
Journal of Applied Physiology 43: 700-703

McNair, D.M., Lorr, M. & Dropplemann, L.F. (1971)
Profile of Mood States Manual. San Diego. Education and Testing Services.

Mechanic, D.; Cleary, P.D. (1980) Factors Associated with the Maintenance of Positive Health Behavior
Preventive Medicine 9 :805-814

Meredith, M.D. (1988) Activity of Fitness: is the Process or the Product More Important for Health?
Quest 40 :180-186

Milesis, C.A., Pollock, M.L., Bah, M.D., Ayres, J.J., Ward, A & Linnerud, A.C (1976) Effects of Different Durations of Physical Training on Cardiorepiratory Function, Body Composition and Serum Lipids
Research Quarterly 47: 716-725

Mills, G. & Wilkinson, P. (1966) Plasma Lipid Levels and the Diagnosis of Coronary Arterioscerosis in England
British Heart Journal 28: 638-645

Moore, C.E.; Hartung, G.H.; Mitchell, R.E.; Kappus, C.M.; Hinderlitter, J. (1983) The Relationship of Exercise and Diet on High-density Lipoprotein Cholesterol Levels in Women
Metabolism 32 :189-196

Morgan, W.P. & Pollock, M.L. (1977) Psychological Characterisation of Elite Distance Runners
Annals of the New York Academy of Sciences 301: 382-403

Morgan, W.P. (1979) Anxiety Reduction following Acute Physical Activity
Psychiatric Annals 9: 380-389

Morgan, W.P. (1981) Psychological Factors influencing Perceived Exertion
Medicine and Science in Sports 5: 97-103

Morgan, W.P. (1985) Affective Benefience of Vigorous Physical Activity
Medicine and Science in Sports and Exercise 17: 94-100

Morgan, W.P. & Goldson,S. (1987) Chapter 15 In Morgan & Goldson (Eds) Exercise and Mental Health Washington Hemisphere Publishing Corporation

Morgan, D.W. & O'Connor, P.J. (1988) Exercise and Mental Health Ch. 4 In Dishman, R.K. (Ed) Exercise Adherence- Its Impact on Public Health Champaign, Illinois Human Kinetics Books.

Morgan, D.W.; Cruise, R.J.; Glraardin, B.W.; Lutz-Schnelder, V.; Morgan, D.H.; Wang, M.Q. (1986) HDL-C Concentrations in Weight Trained, Endurance Trained and Sedentary Females
Physician and Sports Medicine 14 :166-181

Moses, J.; SteptoeJ.; Mathews, A. & Edwards, S (1989) The effects of Exercise Training on Mental Well-being in the Normal Population
Journal of Psychosomatic Research 33: 47-61

Mullen, B.J., Krantzler, N.J. Grivetti, L.E., Schultz, H.G. & Meiselman, H.L (1984) Validity of a Food Frequency Questionnaire for the determination of individual Food Intake
American Journal of Clinical Nutrition 39: 136-143

Multiple Risk Factor Intervention Trial Research Group : Multiple Risk Factor Intervention Trial: Risk Factor Changes and Mortality Results (1982)
Journal of the American Medical Association 248: 1465-1477

Mutrie, N. (1986) Exercise as a treatment for depression within a National Health Service. Unpublished Doctoral Dissertation. The Pennsylvania State University

Mutrie, N. (1987) The Psychological Effects of Exercise for Women. In MacLeod, D.; Maughan, R.; Nimmo, M.; Reilly. T. & Williams,C (Editors) Exercise: Benefits, Limits and Adaptations. E & F Spon Publishers.

Nachemson,A.L. & Rydevik, S. (1982) Chemonucleolysis for sciatica. A critical review. Acta Orthopaedica Scandinavica 59: 56-62.

Nachemson,A.L. (1990) Exercise, Fitness and Back Pain. Chapter 45, pp 533-540. In Bouchard, Shephard, Stephens et al, (Eds) Exercise, Fitness and Health. Champaign: Human Kinetics Books.

Nash, H.L. (1989) Re-emphasing the Role of Exercise in Preventing Heart Disease Physician and Sports Medicine 17 :219-221

National Back Pain Association (1988)

Nelson, L.; Jennings, G.L.; Esler, M.D.; Korner, P.I. (1986) Effect of Changing Physical Activity on Blood Pressure and Haemodynamics in Essential Hypertension The Lancet 473-477

Nicolalsen, T.; Jorgensen, K. (1985) Trunk Strength, Back Muscle Endurance and Low Back Trouble Scandinavian Journal of Rehabilitation 17 :121-127

Nowlis, D.P. & Greenberg, N (1979) Empirical Description of the Effects of Exercise on Mood Perceptual and Motor Skills 49: 1001-1002

Oldridge, N.B. (1982) Compliance and Exercise in Primary and Secondary Prevention of CHD Preventative Medicine 11 :56-70

Pacy, P.J.; Webster, J. & Garrow, J.S. (1986) Exercise and Obesity Sports Medicine 3: 89-113

Paffenbarger, R.S.; Wing, A.L.; Hyde, R.T. & Jung, D.L. (1983) Physical Activity and the Incidence of Hypertension in College Alumni American Journal of Epidemiology 117: 245-257

Pandolf, H.B., Burke, R.L., Goldman, R.F. (1975) Differentiated Ratings of Perceived Exertion during Physical Conditioning for Older Individuals using Leg Weight Loading Perceptual and Motor Skills 40: 563-574

Pariskova, J. & Poupa, O. (1963) Some Metabolic Consequences of Adaptation to Muscular Work British Journal of Nutrition 18: 341-345

Pate, R.R. (1988) The Evolving Definition of Physical Fitness
Quest 40: 174 - 179

Petrozello, S.J., Landers, D.M., Hatfield, B.D., Kubitz, K.A. & Salazar, W. (1991) A Meta-analysis on the Anxiety Reducing Effects of Acute and Chronic Exercise
Sports Medicine 11: 143-182

Plummer, O.K.; Koh, Y.O. (1987) Effects of Aerobics on Self-concepts of College Women
Perceptual and Motor Skills 65 :271-275

Pollock, M.L., Miller, H.S., Janeway, R. & Linnerud, A.C. (1971) Effects of Walking on Body Composition and Cardiovascular Function of Middle-aged Men
Journal of Applied Physiology 30: 126-130

Pollock, M.L. (1973) The Quantification of Endurance Training Programs
Exercise and Sports Science Reviews 1: 155-158

Pollock, M.L.; Wilmore, J.M.; Fix, S.M. (1978) Health and Fitness Through Physical Activity
John Wiley and Sons New York

Pollock, M.L.; Wilmore, J.M.; Fox, S.M. (1984)
Exercise in Health and Disease
W.B. Saunders Co. Philidelphia

Pollock, M.L., Jackson, A.S. & Foster, C. (1986) The use of the Perception Scale for Exercise Prescription p 162 In Borg, G & Ottoson (Eds) The Perception of Effort in Physical Work. London. Macmillan Press Ltd

Powell, K.E.; Caspersen, C.J.; Koplan, J.P.; Ford, E.S. (1989) Physical Activity and Chronic Diseases
American Journal od Clinical Nutrition 49 :999-1006

Powell, K.E.; Thomson, P.D.; Caspersen, C.J.; Kendrick, J.S. (1987) Physical Activity and the Incidence of Coronary Heart Disease
Annual Review of Public Health 8 :253-287

Prior, J.C.; Vigna, Y. (1985) Gonadal Steroids in Athletic Women. Contraception, Complications and Performance
Sports Medicine 2 :287-295

Raglin, J.S. (1990) Exercise and Mental Health: Beneficial and Detrimental Effects
Sports Medicine 9: 323-329

Raglin, J.S.; Morgan, W.P. (1987) Influence of Exercise and Quiet Rest on State Anxiety and Blood Pressure
Medicine and Science in Sports and Exercise 19 :456-463

Ravussen, E., Burnand, B., Schutz, Y & Jequier, E. (1982) Twenty Four Hour Energy Expenditure and Resting Metabloic Rate in Obese, Moderately Obese and Control Subjects
American Journal of clinincal Nutrition 35: 566-573

Reilly, T , Robinson, G & Minar. D.S. (1984) Some Circulatory Responses to Exercise at Different Times of Day
Medicine and Science in Sports and Exercise 16: 477-482

Registrar General for Scotland - Annual Reports HMSO

Rejeski, W.J. & sanford, B. (1984) Feminie-typed Females : The Role of Affective Schema in the Perception of Exercise Intensity
Journal of sports Psychology 6: 197-207

Reuter, M.A., Mutrie, N., Harris, D. (1982) Running as an adjunct to counseling in the treatment of depression.
Unpublished manuscript, The Pennsylvania State University. Cited by Mutrie, N. (1987) in MacLeod et al (Eds) Exercise: Benefits, Limitations and Adaptations. London, E. & F. Spon.

Review panel on coronary-Prone Behavior and Coronary Heart Disease (1981) Coronary-prone Behavior and Coronary Heart Disease- A Critical Review
Circulation 63: 1199-1214

Roberts, W.C. (1987) Frequency of Systemic Hypertension in Various Cardiovascular Diseases
American Journal of Cardiology 60: 1E-8E.

Rockefeller, K.A. & Burke, E.J. (1979) Psycho-Physiological Analysis of an aerobic Dance Programmme for Women
British Journal of Sports Medicine 13: 77-80

Roman, O.; Camuzzi, A.L.; Villalon, E. & Klenner, C (1981) Physical Training Programme in Arterial Hypertension. A Long Term Prospective Follow-up
Cardiology 67: 230-243

Ross, C.E.; Haynes, D. (1988) Exercise and Pschologic Well-being in the Community
American Journal of Epidemiology 127 :726-771

Rosenman, R.H., Brand, R.J., Jenkins, C.D., Straus, R & Wurm, K. (1975) Coronary Heart Disease in the Western Collaboration Group Study: Final Follow-up Experience of 8 1/2 years
Journal of the American Medical Association 233: 872-877.

Roth, D.L.; Holmes, D.S. (1985) Influence of Physical Fitness in Determining the Impact of Stressful Life Events on Physical and Psychological Health
Psychosomatic Medicine 47 :164-173

Rowell, L.B. (1974) Human Cardiovascular Adjustments to Exercise and Thermal Stress
Physiologiacal Reviews 54: 75-159

Sachs, M.L. (1984) The Runners High. In Sachs, M.L & Buffone, G.W. (Eds) Running as Therapy. Lincoln, University of Nebrask Press.

Sady, S.P., Wortman, M. & Blanke, D. (1982) Flexibility Training: Ballistic, Static or Propriceptor Neuromuscualr Facilitation
The Archives of Physical Medicine and Rehabilitation 63: 261-263

Sallis, J.F., Haskell, W.L., Wood, P.D., Fortmann, S.D. & Vranizan, K.M (1986) Vigorous Physical Activity and Cardiovascular Risk Factors in Young Adults
Journal of Chronic diseases 39: 115-120

Sallis, J.F., Haskell, W.L., Wood, P.D., Fortmann, S.D. & Vranizan, K.M (1986) Moderate Intensity Physical Activity and Cardiovascular Risk Factors: The Stamford Five City Project
Preventive Medicine 15: 561-568.

Saltin, B, Hartley, L.H., Kilbom, A & Astrand, I. (1969)Physical Training in Sedentary Middle-aged and Older Men. Oxygen Uptake, Heart Rate and Blood Lactate Concentrationat Sub-maximal amd Maximal Exercise
Acta Physiologica Scandinavica 24: 323-334

Saltin, B, Nazar, K, Costill, D.L. Stein, E., Jansson, E., Essen, B. & Gollnick, P.D. (1976) The nature of the Training Response: Peripheral and Central Adptations to One Legged Exercise
Acta Physiologica Scandinavica 96: 289-305

Santiago, M.C., Leon,A.S. & Serfass, R.S. (1989) Effects of a 40 week Walking Programme on Physical Fitness, Body Composition and Blood Lipids in Women Paper presented at the 36th Annual Meeting of the American College of Sports Medicine
Medicine and science in Sports and Exercise 21(suppl): S75 (Abstract)

Sapega, A.A., Quaedenfeld, T.C., Moyer, R.A. & Butler, R.A. (1981) Biophysical Factors in Range of Motion Exercise
Physician and Sportsmedicine 9: 57-65

Scheuer, J & Tipton, C.M. (1977) Cardiovascular Adaptations to Physical Training
Annual Review of Physiology 39: 221-251.

Scnabel, A. & Kinderman, W (1982) Effect of Maximal Oxygen Uptake and Different Forms of Physical Training on Serum Lipids
European Journal of Applied Physiology 48: 263-277

Scottish Health Education Group Beating Heart Disease. Information Booklet

Sharkey, B.S. (1984) Physiology of Fitness. 2nd. ed. Human Kinetics Publications Inc. Champaign

Shephard, R.J. (1987) Exercise Physiology
Toronto : B.C. Decker Inc.

Shephard, R.J., Berridge, M. & Montelpare, W. (1990) On the Generality of the Sit and Reach Test: An Analysis of Flexibility Data for an Ageing Population
Research Quarterly for Exercise and Sport 61: 326-330.

Simonelli, C. & Eaton, R.P. (1978)Reduced Triglyceride Secretion : A Metabolic Consequence of Chronic Exercise
American Journal of Phyiology 254: E221-E227

Simons, C.W. & Birkimer, J.C. (1988) An Exploration of Factors Predicting the Effects of Aerobic Conditioning on Mood State
Journal of Psychosomatic Research 32: 63-75

Sinning, W.E. & Wilson, J.R. (1984) Validity of "Generalized" Equations for Body Composition Analysis in Women Athletes.
Medicine and Science in Sports and Exercise 55: 153-160

Smith, W.C.S.; Tunstall-Pedoe, H.; Crombie, I.K.; Tavendale, R. (1989) Concomitants of Excess Coronary Deaths - Major Risk Factor and Lifestyle Findings from 10,359 Men and Women in the Scottish Heart Disease Health Study
Scottish Medical Journal 34 :550-555

Sonstoem, R.J (1984) Exercise and Self-esteem
Exercise and Sports Science Reviews 12: 123-155.

Spielberger, C.D. Gorsuch, R.L. & Luschene, R. (1970) State-trait anxiety inventory manual. Pala Alto: Consulting Psychologists Press

Stamford, B. (1984) Flexibilty and Stretching
Physician and Sportsmedicine 12: 171

Stamler,J.; Neaton, J.D. & Wentworth, D.N. (1989) Blood Pressure (Systolic and Diastolic) and Risk of Fatal Coronary Heart Disease
Hypertension 13 (Suppl I) I2-I12

Stefanik, P.A., Trulson, M.F. & Kosovsky, C. (1963) Determining the Frequency Intakes of Foods in Large Group Studies
American Journal of Clinical Nutrition 11: 335-343

Stein, R.A.; Michielli, D.; Diamond, J.; Horwittz, B. & Krasnow, N. (1980) The Cardiac Response to Exercise Training.
American Journal Of Cardiology 63: 254-256

Stephens, T. (1988) Physical Activity and Mental Health in the United States and Canada: Evidence from Four Population Surveys
Preventive Medicine 17: 35-47.

Steptoe, A & Bolton, J (1988) The Short Term Influence of High and Low Intensity Physical Exercise on Mood
Psychology and Health 2: 91-106

Steptoe, A & Cox, S (1988) Acute Effects of Exercise on Mood
Health Psychology 7: 329-340

Surburg, P.R. (1983) Flexibility Exercise Re-examined
Athletic Training 18: 37-40

Tanaka, K.; Nakadomo, F.; Maeda, K. (1988) Effects of Jogging/Running Training on Cardiorespiratory Fitness, Serum Lipids and Body Composition in Healthy Males
Annales of Physiology and Anthropology 7 :31-37

Taylor, C.B., Sallis, & Needles, R. (1985) The Relation of Physical Activity and Exercise to Mental Health
Public Health Reports 100: 195-202

Thow, M, Newton, M & Nimmo, M (1988) An Investigation into the Physiological and Mood Psychological Changes Associated with Different Types of Aerobic Exercise in Females
Scottish Journal of Physical Education 16: 24-28

Tipton, C.M. (1984) Exercise, Training and Hypertension pp 245 - 306 In Terjung, T.R. (Editor) Exercise and Sports Science Reviews. Lexington. The Collarmore Press

Titchenal, C.A. (1988) Exercise and Food Intake. What is the Relationship?
Sports Medicine 6 :135-145

Tran, Z.V., Weltman, A., Glass, G.V. (1983) The Effects of Exercise on Blood Lipids and Lipoproteins. A Meta-analysis of Studies
Medicine and Science in Sports and Exercise 15: 393-403

Tremblay, A., Despres, J.P. & Bouchard, C. (1985) The Effects of Exercise Training on Energy Balance and Adipose Tissue Morphology and Metabolism
Sports Medicine 2: 223-233

Trivedi, B. & Danforth, W.H. (1966) Effect of pH on the Kinetics of Frog Muscle Phosphofructokinase
Journal of Biological Chemistry 241: 4110 - 4112

Tunstall-Pedoe, H.; Smith, W.C.S.; Crombie, I.K.; Tavendale, R. (1989) Coronary Risk Factor and Lifestyle Variation across Scotland: Results from the Scottish Heart Health Study
Scottish Medical Journal 34 :556-560

Vaccaro, P.; Clinton, M. (1981) The Effects of Aerobic Dance Conditioning on the Body Composition and Maximal Oxygen Uptake of College Women
Journal of Sports Medicine 21 :291-193

Vander, A.J., Sherman, J.H & Luciano, D.S. (1985) Human Physiology - The Mechanisms of Body Function (4th Edition) New York. McGraw-Hill.

Vodak, P.A., Wood, P.D.; Haskell, W.L. & Williams, P.T. (1980) HDL-Cholesterol and Other Plasma Lipids and Lipoprotein Concentrations in Middle-aged Male and Female Tennis Playres
Metabolism 21: 745-752

Wagemaker, H. & Goldstein, L. (1980) The Runners High
Journal of Sports Medicine and Physical Fitness 20: 227-229

Watson, A.W.S. (1983) Physical Fitness and Athletic Performance London. Longmans.

Wearing, M.P.; Yuhosz, M.D.; Campbell, R.; Love, E.J. (1972) Effect of the Menstrual Cycle on Tests of Physical Fitness
Journal of Sports Medicine 12 :38-41

Weber, J.C. & Lee, R.A. (1968) Effects of Differing Prepuberty Exercise on the Emotionality of Male Albino Rats
Research Quarterly 39; 748 - 751

Wells, K.F. & Dillon, E.K. (1952) The Sit and Reach Test- A Test of Back and Leg Flexibility
Research Quarterly 23: 115-118.

Wells, C.L. (1991) Women, Sport and Performance. A Physiological Perspective (2nd Edition) Champaign. Human Kinetics Books

Weltman, A.; Weltman, J.; Rutt, R.; Selp, R.; Levine, S.; Snead, D.; Kalser, D.; Rogel, A. (1989) Percentages of Maximal Heart Rate Reserve and VO2 Peak for Determining Endurance Training Intensity in Sedentary Women
International Journal of Sports Medicine 10 :212-216

Wenger, H.A. & MacNab, R.B.J. (1975) Endurance Training: The Effects of Intensity, Total Work, Duration and Physical Fitness
Journal of Sports Medicine and Physical Fitness 15: 199-211.

Wenger, H.A.; Bell, G,J, (1986) The Interactions of Intensity, Frequency and Duration of Exercise Training in Altering Cardiorespiratory Fitness
Sports Medicine 3 :346-356

Williams, J.G. & Eston, R.G. (1989) Determination of the Intensity Dimension in Vigorous Exercise Programmes with Particular Reference to the Use of the Rating of Perceived Exertion
Sports Medicine 8: 177-189.

Williams, L.D.; Morton, A.R. (1986) Changes in Selected Cardiorespiratory Responses to Exercise and Body Composition Following a 12 Week Aerobic Dance Program
Journal of Sports Sciences 4 :189-199

Williams, P.T.; Wood, P.D.; Haskell, W.L.; Vranizan, K. (1982) The Effects of Running Milage and Duration on Plasma Lipoprotein Levels
Journal of the American Medical Association 247 :2674-2676

Williams, P.T.; Krauss, R.M.; Wood, P.D.; Lingren, F.T.; Glotas, C & Vranizam, K.M. (1985) Lipoprotein Subfractions of Runners and Sedentary Men
Metabolism 34: 1024-1029

Williams, P.T., Krauss, R.M., Wood, P.D., Lingren, F.T., Giotas, C & Vranzan, K.M. (1986) Lipoprotein Sub-Fractions of Runners and Sedentary Men
Metabolism 35: 45-52

Williford, H.N.; Blessing, D.L.; Barksdale, J.M.; Smith, F.H. (1988) The Effect of Aerobic Dance Training on Serum Lipids, Lipoproteins and Cardiopulmonary Function
Journal of Sports Medicine 28 :151-157

Wilkinson, P. (1966) Plasma Lipid Levels and the Diagnosis of Coronary Atheraosclerosis in England British Heart Journal 28: 638-645

Wilmore, J.H. (1974) Alterations in Strength, Body Composition and Anthropometric Measurements consequent to a 10 week Weight Training Programme Medicine and Science in Sports 6: 133-138

Wilmore, J.H. (1977) Training for Sport and Activity. 2nd Edn. Boston. Allyn & Bacon Inc.

Wilmore, J.H., Parr, r.B., Girandola, R.N., Ward, P., Vodak, P.A., Pipes, T.V., Romerom, G.T. & Leslie, P.(1978) Physiological Alterations consequent to Circuit Weight Training Medicine and Science in Sports 10: 79-84.

Wilmore, J.H. (1982) Training for Sports and Activity : The Physiological Basis of the Conditioning Process, (2nd Edition) Boston: Allyn & Bacon Inc.

Wilmore, J.H. & Thomas, E.L. (1987) Important Differences between Men and Women for Exercise Testing and Exercise Prescription. In Skinner, J.S (Editor) Exercise Testing and exercise prescription for special cases. Theoretical Basis and Clinical Applications Lea & Febiger, Philadelphia

Wilson, V.E., Morley, M.C. & Bird, E.I. (1980) Mood Profile of Marathon Runners, Joggers and Non-exercisers Perceptual and Motor skills 53: 472-474.

Wingard, D.L. (1990) Sex Differences and Coronary Heart Disease: A Case of Comparing Apples and Pears Circulation 81 :1710-1712

Wirth, J.C. & Lohman, T.G. (1982) The Relationship of Static Muscle Function to the Use of Oral Contraceptives Medicine and Science in Sports and Exercise 14: 16-20

Wood, P.D.; Haskell, W.L.; Blair, S.N.; Williams, P.T.; Krauss, R.M. et al (1983) Increased Exercise Level and Increased Lipoprotein Concentrations: A One Year Randomised, Controlled Study in Sedentary Middle aged Men Metabolism 32: 31-39

Wood, P.D. & Stefanick, M.L. (1990) Exercise, Fitness and Atherosclerosis. In Bouchard et al (Editors) Exercise, Fitness and Health. A Consensus of Current Knowledge. Human Kinetics Publ., Champaign, Illinois.

Woods, N.G.; Graham, T.E. (1986) Effect of Menstrual Phase and Exercise Training on Serum Lipids Canadian Journal of Applied Sport Science 11 :88-93

Wynn, V; Mills, G.L. & Doar J.W.H. (1969) Fasting Serum Triglycerides, Cholesterol and Lipoproteins During Oral Contraceptive Therapy
The Lancet 2: 756-760

Wynne, T.P., Frey, M.A.B., Laubach, L.L., (1980) Effect of a Controlled Exercise Programme on Serum Lipoproteins Levels in Women on Oral Contraceptives. Metabolism 29: 1267-1271.

APPENDIX A

WOMEN'S FITNESS STUDY - THE EFFECTS OF AN EXERCISE PROGRAMME ON PREVOUSLY SEDENTARY WOMEN.

FORM OF CONSENT

The purpose of this study is to test the effects of an exercise programme on health-related fitness variables including CHD risk factors and psychological variables.

Exercise Test (Exercisers and controls).

The test involves 6-11 minutes of sub-maximal cycling with a progressive increase in workload. You will be able to terminate this test at any time if you so wish. Body fat, sit-up and flexibility tests will also be conducted. A fasting blood sample will also be taken by qualified personnel. Two tests will be conducted twelve weeks apart.

Training Programme (Exercisers only).
The study will last for 12 weeks during which time you will be asked to exercise in Popmobility and/or Tune-up sessions three times per week. Periodically, during this time your heart rate will be monitored and you will be expected to complete a training diary.

Consent

I, ______________________of__________________________

give my consent to the research procedures described above, the nature, purpose and possible consequences of which have been described to me by

____

Signed____________________ Date____________________

Witness___________________

APPENDIX B

WOMEN'S FITNESS STUDY

INFORMATION FOR SUBJECTS

On the day of your assessment

You should **not**

- Undertake any strenuous activity
- Eat in the 2-3 hours preceding the assessment
- Smoke in the 2 preceding the assessment
- Consume drinks containing caffeine in the 2 hours preceding the assessment

You **should**

- Wear suitable clothing and gym shoes (e.g. A track suit or short and T-shirt - **Not** a leotard

The assessment will consist of a blood pressure measurement, a bicycle test (aerobic power or the efficiency of the heart and lungs), a sit-up test (abdominal muscular endurance), a Sit and Reach test (flexibility) and an estimate of body fat.

Additionally you will be given questionnaires on Mood State, Food frequency and Smoking to complete.

Please note You will not be given any of your results until after the study period (12 weeks).

Some of you will be asked to give a small, fasting sample of your blood on a separate occasion.

NAME____

DATE AND TIME
OF APPOINTMENT________________________________

All Fitness Assessments will take place in the Human Performance Laboratory, Kelvin Hall. The Lab. is situated at the back of the Conditioning Suite (Weights Room), opposite side to the running track and slightly further along.

APPENDIX C

SMOKING QUESTIONNAIRE

Please tick the correct answer.

1(a). Do you smoke cigarettes now ?

Yes, regularly ___

Yes, occasionally ___

No ___

If "no" , go to question 2

1(b). Would you like to give up cigarettes ?

Yes ___

No ___

2(a). Did you ever smoke cigarettes ?

Yes ___

No ___

If "no", go to question 3

2(b). When did you stop smoking cigarettes ?

____

2(c). Why did you stop smoking cigarettes ?

____

3. Have you ever smoked any other tobacco products ?

Yes ___

No ___

If "yes", please specify________________________

END OF QUESTIONNAIRE

APPENDIX D

FOOD FREQUENCY QUESTIONNAIRE

The following questions are about the food you usually eat. Please give the number of days each week you usually eat each food. Cicle your answer.

Example: If you eat a food every day,then circle 7	7 6 5 4 3 2 1 M R N
If you eat a food 4 days a week, circle 4	7 6 5 4 3 2 1 M R N
If you eat a food infrequently,ie less than once a week, but more than once a month, circle M	7 6 5 4 3 2 1 M R N
If you rarely eat a food, ie less than once a month, circle R	7 6 5 4 3 2 1 M R N
If you never eat a food, circle N	7 6 5 4 3 2 1 M R N

If, when you eat a food, you may have more than one portion. Please indicate this in the section headed "How many".

eg. 4 digestive biscuits each week day

		How many
Digestive	7 6 5 4 3 2 1 M R N	

4 pints of beer on Friday and Saturday

		How many
Beer,stout,cider	7 6 5 4 3 2 1 M R N	

Please complete all questions

NAME____

DATE____

BREAD

		How many rolls or slices per day?	Size of slice
1. White	7 6 5 4 3 2 1 M R N	___________	thick medium thin
2.Wholemeal/ Hi-bran/ Mighty White	7 6 5 4 3 2 1 M R N	___________	thick medium thin
3. Brown/wheatgerm Hovis/Granary	7 6 5 4 3 2 1 M R N	___________	thick medium thin
4 White rolls	7 6 5 4 3 2 1 M R N	___________	small large
5. Wholemeal rolls	7 6 5 4 3 2 1 M R N	___________	small large
6. Brown rolls	7 6 5 4 3 2 1 M R N	___________	small large
7. Crispbread/Ryvita creamcrackers/ water biscuits	7 6 5 4 3 2 1 M R N	___________	
8. Brown wheat crackers	7 6 5 4 3 2 1 M R N	___________	
9. Pizza	7 6 5 4 3 2 1 M R N	___________	
10. Pitta bread	7 6 5 4 3 2 1 M R N	___________	white wholemeal
11. Chapatis/ nan bread	7 6 5 4 3 2 1 M R N	___________	

12. What do you usually spread on bread? butter margarine low fat spread

BREAKFAST CEREALS

13. How often do you have a cereal (including porridge) for breakfast?

7 6 5 4 3 2 1M R N

14. Do you often have a cereal at times other than breakfast ? Yes No

15. State which cereal you usually have ______________________________

16.How many spoonfuls of sugar do you take on your cereal or porridge? ___________

BISCUITS AND CAKES

		How many per day ?
17. Plain biscuits eg Rich tea/ Abernethy	7 6 5 4 3 2 1 M R N	_____________
18.Oatcakes	7 6 5 4 3 2 1 M R N	_____________
19. Plain digestive	7 6 5 4 3 2 1 M R N	_____________

39. Please name any other fruit you eat

__________ 7 6 5 4 3 2 1 M R N

__________ 7 6 5 4 3 2 1 M R N

__________ 7 6 5 4 3 2 1 M R N

__________ 7 6 5 4 3 2 1 M R N

40. Tinned fruit 7 6 5 4 3 2 1 M R N With sugar In own juice

VEGETABLES

		How many times per day?
41. Potatoes- baked/boiled/mashed	7 6 5 4 3 2 1 M R N	__________
42. Potatoes- roast	7 6 5 4 3 2 1 M R N	__________
43. Potatoes- chips	7 6 5 4 3 2 1 M R N	__________
44. Root vegetables (turnip/carrot/ parsnip/beetroot)	7 6 5 4 3 2 1 M R N	__________
45. Onions-raw/ cooked/pickled	7 6 5 4 3 2 1 M R N	__________
46. Fresh/frozen green vegetables	7 6 5 4 3 2 1 M R N	__________
47. Tinned vegetables (including baked beans/ butter beans/kidney beans/ sweetcorn/peas)	7 6 5 4 3 2 1 M R N	__________

48. Do you add anything to cooked vegetables?

Butter margarine low fat spread nothing

PASTA AND RICE

49. White macaroni/ spaghetti/other pasta	7 6 5 4 3 2 1 M R N	__________
50. Wholewheat macaroni/ spaghetti/other pasta	7 6 5 4 3 2 1 M R N	__________
51. White rice(boiled or fried -not rice pudding)	7 6 5 4 3 2 1 M R N	__________
52. Brown rice	7 6 5 4 3 2 1 M R N	__________

SOUPS

		Home made	tinned
53.Cream soups eg tomato/ mushroom/chicken	7 6 5 4 3 2 1 M R N	_____	_____
54. Lentil/split pea/broth	7 6 5 4 3 2 1 M R N	_____	_____

55. Other-please specify

_________________7 6 5 4 3 2 1 M R N ______ _____

PUDDINGS

56. Mlik pudding eg rice/ custard/tapiaca 7 6 5 4 3 2 1 M R N

57. Ice cream 7 6 5 4 3 2 1 M R N

58. Sponge pudding/crumble 7 6 5 4 3 2 1 M R N

59. Fancy pudding eg gateaux/ cheesecake/pavlova 7 6 5 4 3 2 1 M R N

60.How often do you eat eggs (not including in baking) 7 6 5 4 3 2 1 M R N

61. Please state how you usually cook eggs

Boiled_____ Poached_____ Scrambled_____ Fried_____

MILK

How much of the following types of mil do you use in tea, coffeee, milky drinks and with cereal?

62. Skimmed milk ________pint(s)

63. Semi-skimmed ________pint(s)

64. Whole milk ________pint(s)

65. Do you use any other type of milk? Yes_____ No_____

If so please specify ________ ________pint(s)

CHEESE

How much do you eat in an average week?

66. Cheddar/Cheshire/Stilton _____lb_____oz

67. Edam/Gouda/Caembert _____lb_____oz

68. Processed or cheese spread _____lb_____oz

69 Cottage cheese _____lb_____oz

YOGHURT

How much per day?

70. Yoghurt with sugar 7 6 5 4 3 2 1 M R N ________________

71. Yoghurt without sugar 7 6 5 4 3 2 1 M R N ________________

SPREADS

amount eaten per day
(teaspoons)

72. Honey 7 6 5 4 3 2 1 M R N ________________

73. Peanut butter 7 6 5 4 3 2 1 M R N ________________

74.Fish or meat paste/pate 7 6 5 4 3 2 1 M R N ________________

75. Other-please state 7 6 5 4 3 2 1 M R N ________________

NUTS, CRISPS AND CONFECTIONERY etc.

76. Nuts 7 6 5 4 3 2 1 M R N

77. Crisps/savoury snacks 7 6 5 4 3 2 1 M R N

78. Popcorn 7 6 5 4 3 2 1 M R N

79. Ice cream/ice lollies 7 6 5 4 3 2 1 M R N

80. Sweets/chocolate 7 6 5 4 3 2 1 M R N

DRINKS

81. How many cups/mugs of coffee do you have per day? __________

82. How many teaspooons of sugar do you take per cup/mug? __________

83. How many cups/mugs of tea do you have per day? __________

84. How many teaspoons of sugar do you take per cup/mug? __________

85. How many milky drinks(eg ovaltine) do you have per day? __________

86. How many teaspoons of sugar do you take per cup/mug? __________

How often do you drink the following?

How many
per day?

87. Natural, unsweetened
fruit juice 7 6 5 4 3 2 1 M R N __________ glass(es)

88. Sweetened fruit juice 7 6 5 4 3 2 1 M R N __________ glass(es)

89. Sweetened fruit flavoured drink or squash	7 6 5 4 3 2 1 M R N	________	glass(es)
90. Fizzy drinks, sweetened with sugar(eg coke,lilt)	7 6 5 4 3 2 1 M R N	________	glass(es)
91. Sugar free drinks (eg diet-coke,diet squash)	7 6 5 4 3 2 1 M R N	________	glass(es)
92. Beer,stout or cider	7 6 5 4 3 2 1 M R N	________	glass(es)
93. Wine	7 6 5 4 3 2 1 M R N	________	glass(es)
94. Sherrt,port or vermouth	7 6 5 4 3 2 1 M R N	________	glass(es)
95. Spirits, liqueurs	7 6 5 4 3 2 1 M R N	________	glass(es)
96. Bottled mineral water	7 6 5 4 3 2 1 M R N	________	glass(es)
97. Flavoured milks	7 6 5 4 3 2 1 M R N	________	glass(es)

TAKE AWAY FOOD

98. How often do you eat "take away" food? 7 6 5 4 3 2 1 M R N

99. What would you be most likely to choose?
You may tick more than one item

Pie/bridie/sausage roll_______

Chicken/haggis supper_______

Pizza _______

Quiche _______

Filled roll/ sandwich ______

Fish Supper_________

Baked potato with filling _______

Kebab _______

Chinese _______

Curry/Indian _______

How often do you have home fried food (including chips) cooked with the following?

100.Lard, dripping or solid vegetable fat 7 6 5 4 3 2 1 M R N

101. Cooking oil 7 6 5 4 3 2 1 M R N

102. How often do you have cream? 7 6 5 4 3 2 1 M R N_______ (amount)

103. Do you ever eat the fat on meat?

Never______ Occasionally______ Often_____ Always_______

104 Do you use wholemeal flour in cooking ?

Never______ Occasionally______ Often______ Always_______

SALT

105

How often do you use salt?

Never ___

Only in cooking ___

In cooking and added to meals at the table ___

106 Do you use a salt substitute? Yes______ No______

107. Do you use an artificial sweetener? Yes______ No______

108. Are you on a special diet? Yes______ No______

If yes, please state which of the following?

Slimming diet suggested by your doctor ________

Slimming diet prescribed by yourself ________

Diabetic diet ________

Other medical diet ________

Vegetarian diet ________

109. How long have you been on a special diet? ________

110. Do you observe any religious dietary laws? Yes____ No____

If so, please specify ____

____

____

END OF QUESTIONNAIRE

APPENDIX E

ACTIVITY DIARY WEEK BEGINNING _/_/__

MONDAY RESTING HEART RATE

TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE(HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					
TUESDAY					
TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE(HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					
WEDNESDAY					
TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE (HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					

RATINGS OF PERCEIVED EXERTION (RPE) SCALE

SCORE	RATING	SCORE	RATING
6		14	
7	VERY,VERY LIGHT	15	HARD
8		16	
9	VERY LIGHT	17	VERY HARD
10		18	
11	FAIRLY LIGHT	19	VERY,VERY HARD
12		20	
13	SOMEWHAT HARD		

THURSDAY

TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART(PULSE) RATE (HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					

FRIDAY

TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE(HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					

SATURDAY

TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE(HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					

SUNDAY

TYPE OF	ALONE				
EXERCISE OR	CLASS				
ACTIVITY (MODE)	GROUP				
DURATION OF EXERCISE					
HEART (PULSE) RATE(HR) AND/OR RPE AFTER 20 MINUTES OF EXERCISE		HR	HR	HR	HR
		RPE	RPE	RPE	RPE
COMMENTS eg HOW HARD					

APPENDIX F

Equipment

1. Bicycle Ergometer
   Monark Model Number 515
   Manufactured by Monark Crescent,
   Stockholm,
   Sweden.

2. Blood Pressure Meter :
   Copal Digital Sphygmomanometer,
   Manufactured

3. Heart Rate Monitor and Recorder :
   Sporttester PE 3000,
   Manufactured by Polar Electro KY,
   Finland.

4. Skinfold Caliper
   Maufactured by Holtain Ltd.,

5. Sit and Reach Apparatus
   Designed by Wells & Dillon (1952)

6. Sit-Up Bench :
   Maufactured by Universal Equipment Ltd.,

7. Profile of Mood State Questionnaire :
   Designed by McNair et al, 1971
   Copyright 1983 Educational & Industrial
   Testing Services, San Diego, CA 92107.

All equipment was calibrated before each testing period. In addition, the blood pressure meter and heart rate recording equipment was checked at the start of every day of use.

APPENDIX G

PILOT STUDY

A pilot study was carried out to assess the suitability of the proposed test battery

G. 1. Objectives

1. To determine the specific order of the test items.
2. To determine the total length of time required for the test.
3. To determine the response of subjects to instructions given by the experimenter.
4. To examine any problems the experimenter may encounter with verbal commands.
5. To test the apparatus.
6. To determine the reliability and practicality of the test items.
7. To detemine the reliability of the experimenter.
8. To establish if there is a test effect on any of the test items.

G. 2. Methods

G. 2. 1. Subjects

12 subjects were involved in the pilot study. Nine of the subjects were regular exercisers and the remaining three were sedentary. The subjects consisted of 11 females and one male.

G. 2. 2. Order of testing

1. Blood pressure and resting heart rate.
2. Body weight.
3. Height.
4. Estimated percentage body fat.
5. Estimated maximal oxygen uptake.
6. Sit and Reach test (Flexibilty).
7. Sit up test (Abdominal endurance).

G. 2. 3. Procedure

Subjects were tested on two successive days at the same time of day. Testing was carried out at the Kelvin Hall, Human Performance Laboratory. The methodology employed is described in Chapter Three.

G. 3. RESULTS

Results are presented in Tables G1 - G15.

Table G1

Systolic Blood Pressure (mm Hg)

Subject	Test 1	Test 2
1	115	110
2	123	123
3	136	125
4	110	118
5	103	108
6	107	122
7	111	108
8	114	122
9	130	131
10	133	120
11	122	118
12	94	96

$t = - 0.11$, $p = 0.92$.

There was no significant difference between test 1 and test 2 measures for diastolic blood pressures.

TABLE G2

Diastolic Blood Pressure (mm Hg)

Subject	Test 1	Test 2
1	71	69
2	77	76
3	61	59
4	70	64
5	56	62
6	62	65
7	72	67
8	74	75
9	81	65
10	79	77
11	80	80
12	63	65

t = 1.14 , p = 0.76
There was no significant difference between the measures for distolic blood pressure on day 1 and day 2

TABLE G3

Resting heart rate
(beats per minute)

Subject	Test 1	Test 2
1	62	63
2	69	61
3	58	51
4	89	84
5	58	61
6	68	72
7	60	60
8	67	78
9	62	67
10	67	67
11	77	65
12	41	42

t = 0.32, p = 0.76

There was no significant differences between the measures for resting heart rate for day 1 and day 2.

TABLE G4

Bicep Skinfold (mm)

Subject	Test 1	Test 2
1	5.1	5.1
2	4.7	5.2
3	3.4	3.6
4	9.2	9.3
5	4.1	5.5
6	5.9	5.7
7	8.0	7.0
8	24.2	20.8
9	9.3	8.2
10	5.4	5.4
11	11.0	11.0
12	3.1	3.1

$t = 0.86$, $p = 0.41$
There was no significant difference between the bicep skinfold measures taken on day 1 and day 2

TABLE G5

Tricep skinfold (mm)

Subject	Test 1	Test 2
1	12.8	12.7
2	9.7	9.7
3	5.0	4.7
4	21.0	18.1
5	12.9	13.1
6	12.0	12.0
7	15.8	14.2
8	34.0	34.0
9	15.4	15.8
10	13.6	15.6
11	17.5	15.6
12	10.6	10.2

$t = 1.06$, $p = 0.31$
There was no significant difference between tricep skinfold measures taken on day 1 and day 2.

TABLE G6

Sub-scapular skinfold (mm)

Subject	Test 1	Test 2
1	9.0	8.7
2	9.3	9.4
3	8.7	9.6
4	14.2	14.0
5	12.0	12.1
6	7.4	6.8
7	11.0	11.0
8	26.6	26.2
9	15.4	15.8
10	9.4	9.4
11	11.6	11.2
12	6.8	6.0

$t = 0.84$, $p = 0.42$

There was no significant difference between sub- scapular skinfold taken on day 1 and day 2.

TABLE G7

Supra-iliac skinfold (mm)

Subject	Test 1	Test 2
1	6.9	6.3
2	6.6	6.7
3	7.0	6.7
4	17.3	15.1
5	10.1	13.0
6	6.1	6.1
7	13.6	12.6
8	36.0	35.6
9	19.8	18.2
10	14.0	13.8
11	10.6	10.2
12	7.3	6.9

$t = 0.97$, $p = 0.35$

There was no significant differences between supra-iliac skinfild measures taken on day 1 and day 2.

TABLE G8

Percentage body fat

Subject	Test 1	Test 2
1	21.3	20.9
2	19.8	20.1
3	10.1	10.4
4	31.0	29.9
5	23.4	24.9
6	20.3	19.9
7	27.9	26.9
8	39.8	39.3
9	31.0	30.3
10	26.2	26.7
11	28.5	27.8
12	20.7	20.2

$t = 0.97$, $p = 0.33$

There was no significant difference between percentage body fat taken on day 1 and day 2.

TABLE G9

Steady state heart rate at 1st workload
(between 2 and 3 minutes) [beats per minute]

Subject	Test 1	Test 2
1	100	105
2	95	96
3	88	84
4	133	121
5	101	106
6	106	114
7	96	99
8	105	114
9	100	107
10	102	100
11	110	105
12	73	72

$t = -0.65$, $p = 0.53$

There was no significant difference between the steady state heart rate measured on day 1 and day 2.

TABLE G10

Steady state heart rate on the 2nd workload
(between 2 and 3 minutes) [beats per minute]

Subject	Test 1	Test 2
1	133	135
2	118	114
3	124	122
4	160	135
5	135	137
6	142	147
7	110	111
8	111	130
9	119	115
10	127	131
11	130	125
12	111	120

t = -0.06, p = 0.96
There was no significant difference between steady state heart rate during the 2nd workload on day 1 and day 2.

TABLE G11

Steady state heart rate for the 3rd workload
(between 4 and 5 minutes) [beats per minute]

Subject	Test 1	Test 2
1	160	162
2	156	151
3	151	149
4	174	160
5	157	158
6	170	167
7	135	139
8	159	168
9	161	167
10	156	158
11	160	157
12	152	149

t = 0.29, p = 0.78
There was no significant difference in the steady state heart rate during the final workload on day 1 and day 2.

TABLE G12

Estimated VO2 max (litres/minute)

Subject	Test 1	Test 2
1	3.09	2.98
2	3.73	3.97
3	4.37	4.50
4	1.48	1.54
5	3.17	3.13
6	2.75	2.73
7	3.60	3.38
8	2.57	2.32
9	3.01	2.82
10	3.19	3.13
11	2.54	2.63
12	3.90	4.06

t = 0.38, p = 0.71

There was no significant difference between vo2 max (litres/minute) on day 1 and day 2.

TABLE G13

Estimated VO_2 max (ml/kg/minute)

Subject	Test 1	Test 2
1	44.2	43.1
2	62.7	65.4
3	66.4	67.9
4	23.4	27.3
5	50.6	49.9
6	48.1	49.5
7	57.7	53.1
8	31.4	28.4
9	43.1	40.7
10	52.0	50.7
11	39.3	40.7
12	60.4	62.3

t = 0.03 ; p = 0.97

There was no significant difference between VO_2 max (ml/kg/minute) on day 1 and day 2.

TABLE G14

Sit and Reach test (flexibility)
(cm)

Subject	Test 1	Test 2
1	26	27
2	42	42
3	27	30.5
4	42	43
5	33	35
6	46	47
7	36	38
8	32	34
9	38	40
10	45	45
11	32	30.5
12	35	38

t = -3.75 ; p = 0.0032

There was a significant difference between sit and reach scores on day 1 and day 2. Subjects have shown a test effect. the method of testing was modified for the main study.

TABLE G15

Sit up test (abdominal endurance)
(REPITIONS PER MINUTE)

Subject	Test 1	Test 2
1	31	27
2	40	42
3	45	45
4	36	34
5	43	45
6	55	55
7	34	35
8	27	26
9	34	37
10	46	53
11	22	22
12	32	29

t = - 0.49 ; p = 0.63

There was no significant difference in the sit up scores from day 1 to day 2.

G. 6. 4. Conclusions

1. The order of testing was appropriate.
2. The testing time for the physiological variables was approximately 30 minute.
3. Subjects understood all of the instructions given by the experimenter.
4. The test itms were found to be practical.
5. There were no problems with the equipiment.
6. There were no test effects on the test items, with the exception of the Sit and Reach Test. This item required an ammendment for the main study. For the main study, the experimenter ensured that all subjects had their legs at full extension during the test.

APPENDIX H

RESULTS OT THE INDEPENDENT T-TESTS CARRIED OUT ON ALL MEASURES AT BASELINE

THE MEAN FOR EACH GROUP IS REPORTED

Body weight
Exercise group = 64.26 Kg. t= 0.64, p= 0.53,
Control group = 62.00 Kg. C.I. (-4.9, 9.5)

Sum of skinfolds
Exercise group = 60.76mm t= 1.52, p= 0.14 ;
Control group = 50.58mm C.I. (-3.4, 28.3)

Percentage Body Fat
Exercise group = 30.70% t=1.17, p=0.25 ;
Control group = 28.71% C.I.(-1.5, 5.4)

Resting Heart Rate
Exercise group=73.54 beats per min t = 0.49, p=0.63
Control group =71.94 beats per min C.I. (-5.2, 8.4)

Systolic Blood Pressure
Exercise group =120.73 mm Hg. t = 0.54, p = 0.59 ;
Control group = 118.62 mm Hg. C.I. (-5.8, 8.2)

Diastolic Blood Pressure
Exercise group = 78.86 mm Hg t = 0.48, p = 0.64;
Control group = 77.50 mm Hg C.I. (-4.5, 7.2)

Predicted Vo2 max
Exercise group= 1.84 L/min t = 0.15, p = 0.88;
Control group = 1.82 L/min C.I. (-0.24. 0.28)

Predicted VO2 max corrected for weight
Exercise group = 28.68 ml/kg/min t = 0.25, p = 0.80;
Control group = 29.16 ml/kg/min C.I. (-4.4, 3.5)

Sit and Reach
Exercise group = 34.32cm t = 0.64, p = 0.52;
Control group = 35.94cm C.I. (-6.8, 3.5)

Sit-ups
Exercise group = 19.27 per min t= 0.03, p = 0.97;
Control group = 19.37 per min C.I. (-6.2, 6.0)

Total Cholesterol

Exercise group= 5.72 mmol/L   t = 1.94, p = 0.068,
Control group = 4.99 mmol/L   C.I. (-0.06, 1.53)

Plasma Triglycerides

Exercise group = 0.97 mmol/L   t = 1.68, p = 0.13,;
Control group = 0.72 mmol/l   C.I. (-0.09, 0.59)

Steady State Heart Rate

1st workload

Exercise group = 108.86   t = 1.09, p = 0.28
Control group = 104.5   C.I. (-3.8, 12.5)

2nd workload

Exercise group = 125.5   t = 0.93, p = 0.36
Control group = 121.44   C.I. (-4.8, 12.9)

3rd workload

Exercise group = 148.32   t = 0.09, p = 0.93
Control group = 148.08   C.I. (-8.0, 7.4)

Profile of Mood State Factors

Composed - Anxious

Exercise group = 49.11   t = 0.65, p = 0.52;
Control group = 48.53   C.I. (-5.1, 9.7)

Agreeable - Hostile

Exercise group = 47.56   t = 0.25, p = 0.80 ;
Control group = 47.27   C.I. (-6.8, 8.7)

Elated - Depressed

Exercise group = 47.78   t = -0.12, p = 0.98;
Control group = 47.93   C.I. (-8.2, 7.3)

Confident - Unsure

Exercise group = 47.06   t =- 0.36, p = 0.72;
Control group = 49.00   C.I. (-7.5, 5.3)

Energetic - Tired

Exercise group = 45.77   t =-0.68, p = 0.50 ;
Control group = 49.33   C.I. (-8.6, 4.3)

Clearheaded - Confused

Exercise group = 50.89
Control group = 51.20

t = -0.25, p = 0.80;
C.I. (-7.2, 5.6).

There were no significant differences between the exercise and control groups before the exercise programme in any of the variables tested.

APPENDIX J.

RESULTS OF INDEPENDENT T-TESTS ON TEST 2 RESULTS ON ALL MEASURES

THE MEAN FOR EACH GROUP IS REPORTED.

Body weight (kg)

Exercise group = 63.48 t=0.49 ; p=0.63 ;
Control group = 61.89 C.I. (-5.0, 8.2)

Sum of Skinfolds (mm)

Exercise group = 53.21 t=0.76 ; p=0.45 ;
Control group = 48.93 C.I. (-7.1, 15.2)

Estimated Percentage Body Fat

Exercise group = 29.03 t=0.39 ; p=0.70 ;
Control group = 28.41 C.I. (-2.6, 3.9)

Resting Heart Rate (beats per minute)

Exercise group = 70.50 t=0.87 ; p=0.39 ;
Control group = 73.04 C.I. (-8.6, 3.5)

Systolic Blood Pressure (mm Hg)

Exercise group = 118.55 t=0.43 ; p=0.67 ;
Control group = 117.19 C.I. (-5.0, 7.7)

Distolic Blood Pressure (mm hg)

Exercise group = 73.76 t = 0.13 ; p = 0.90 ;
Control group = 73.00 C.I. (-5.2, 5.9)

Steady State Heart Rate (beats per minute)

1st Workload

Exercise group = 100.86 t = 0.41 ; p = 0.69 ;
Control group = 104.06 C.I. (-5.5,8.3)

2nd Workload

Exercise group = 116.15 t = 0.10 ; p = 0.92 ;
Control group = 121.37 C.I. (-8.6,7.8)

3rd Workload

Exercise group = 134.82 t = -5.37 ; p=0.001* ;
Control group = 144.94 C.I. (-16.8, -2.4)

VO_2 max (litres/minute)

Exercise group = 2.14 t = 2.05 ; p = 0.048 ;
Control group = 1.84 C.I. (0.00, 0.59)

VO_2 max (ml/kg/minute)

Exercise group = 33.75 t = 1.75 ; p = 0.09 ;
Control group = 30.10 C.I. (-0.6, 7.9)

Sit and Reach Test (cm)

Exercise group = 37.91 t = 1.24 ; p = 0.22 ;
Control group = 35.06 C.I. (-1.8, 7.5)

Abdominal Endurance (repitions per minute)

Exercise group = 26.06 t = 1.37 ; p = 0.18
Control group = 21.56 C.I. (-2.3, 11.3)

Total Cholesterol (mmol/litre)

Exercise group = 5.67 t = 1.84 ; p = 0.09 ;
Control group = 4.67 C.I. (-0.18, 2.18)

Plasma Triglycerides (mmol/litre)

Exercise group = 0.91 t = 0.64 ; p = 0.54 ;
Control group = 0.86 C.I. (-0.30, 0.53)

PROFILE OF MOOD STATES :

Composed-Anxious

Exercise group = 54.68 t= 0.22 ; p=0.82 ;
Control group = 53.93 C.I. (9.7, -7.8)

Agreeable-Hostile

Exercise group = 52.79 t= 0.12 ; p=0.91 ;
Control group = 52.60 C.I. (9.4,-8.4)

Elated-Depressed

Exercise group = 55.79 t= 2.54 ; p=0.018* ;
Control group = 46.53 C.I. (1.8, 17.5)

Confident-Unsure

Exercise group = 54.10 t=1.15 ; p=0.26 ;
Control group = 49.40 C.I. (-3.5,12.5)

Energetic-Tired

Exercise group = 56.58 t= 3.57 ; p= 0.0015* ;
Control group = 45.73 C.I. (4.4, 16.3)

Clearheaded-Confused

Exercise group = 56.10 t=0.99 ; p= 0.33 ;
Control group = 52.80 C.I. (-3.5, 10.1)

*** Groups significantly different (p < 0.05) after 12 weeks.**

APPENDIX K

INITIAL TELEPHONE SURVEY

1. Have you recently (within the last 3 months) engaged in any strenuous exercise or sports (eg games such as squash, badminton ; exercise such as swimming, jogging, exercise classes, weight training).

2. If you have participated in any of these activities, how many times per week did you participate and how long did each session last ?

NAME ______________________________ DATE ______________

IDENTIFICATION

⓪	⓪	⓪	⓪	⓪	⓪	⓪	⓪	⓪
①	①	①	①	①	①	①	①	①
②	②	②	②	②	②	②	②	②
③	③	③	③	③	③	③	③	③
④	④	④	④	④	④	④	④	④
⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨

Below are words that describe feelings and moods people have. Please read EVERY word carefully. Then fill in ONE space under the answer which best describes how you have been feeling DURING THE PAST WEEK INCLUDING TODAY.

Suppose the word is *happy.* Mark the one answer which is closest to how you have been feeling DURING THE PAST WEEK INCLUDING TODAY.

The numbers refer to these phrases:

0 = Much unlike this
1 = Slightly unlike this
2 = Slightly like this
3 = Much like this

MARKING DIRECTIONS

- USE A NO. 2 PENCIL ONLY.
- MAKE NO STRAY MARKS.
- ERASE CLEANLY.

CORRECT MARK ⓪①②●

INCORRECT MARK ⊗✓◉◑

	MUCH UNLIKE THIS	SLIGHTLY UNLIKE THIS	SLIGHTLY LIKE THIS	MUCH LIKE THIS
1. Composed	⓪	①	②	③
2. Angry	⓪	①	②	③
3. Cheerful	⓪	①	②	③
4. Weak	⓪	①	②	③
5. Tense	⓪	①	②	③
6. Confused	⓪	①	②	③
7. Lively	⓪	①	②	③
8. Sad	⓪	①	②	③
9. Friendly	⓪	①	②	③
10. Tired	⓪	①	②	③
11. Strong	⓪	①	②	③
12. Clearheaded	⓪	①	②	③
13. Untroubled	⓪	①	②	③
14. Grouchy	⓪	①	②	③
15. Playful	⓪	①	②	③
16. Timid	⓪	①	②	③
17. Nervous	⓪	①	②	③
18. Mixed-up	⓪	①	②	③
19. Vigorous	⓪	①	②	③
20. Dejected	⓪	①	②	③
21. Kindly	⓪	①	②	③
22. Fatigued	⓪	①	②	③
23. Bold	⓪	①	②	③
24. Efficient	⓪	①	②	③
25. Peaceful	⓪	①	②	③
26. Furious	⓪	①	②	③
27. Lighthearted	⓪	①	②	③
28. Unsure	⓪	①	②	③
29. Jittery	⓪	①	②	③
30. Bewildered	⓪	①	②	③
31. Energetic	⓪	①	②	③
32. Lonely	⓪	①	②	③
33. Sympathetic	⓪	①	②	③
34. Exhausted	⓪	①	②	③
35. Powerful	⓪	①	②	③
36. Attentive	⓪	①	②	③
37. Serene	⓪	①	②	③
38. Bad tempered	⓪	①	②	③
39. Joyful	⓪	①	②	③
40. Self-doubting	⓪	①	②	③
41. Shaky	⓪	①	②	③
42. Perplexed	⓪	①	②	③
43. Active	⓪	①	②	③
44. Downhearted	⓪	①	②	③
45. Agreeable	⓪	①	②	③
46. Sluggish	⓪	①	②	③
47. Forceful	⓪	①	②	③
48. Able to concentrate	⓪	①	②	③
49. Calm	⓪	①	②	③
50. Mad	⓪	①	②	③
51. Jolly	⓪	①	②	③
52. Uncertain	⓪	①	②	③
53. Anxious	⓪	①	②	③
54. Muddled	⓪	①	②	③
55. Ready-to-go	⓪	①	②	③
56. Discouraged	⓪	①	②	③
57. Good-natured	⓪	①	②	③
58. Weary	⓪	①	②	③
59. Confident	⓪	①	②	③
60. Businesslike	⓪	①	②	③
61. Relaxed	⓪	①	②	③
62. Annoyed	⓪	①	②	③
63. Elated	⓪	①	②	③
64. Inadequate	⓪	①	②	③
65. Uneasy	⓪	①	②	③
66. Dazed	⓪	①	②	③
67. Full of pep	⓪	①	②	③
68. Gloomy	⓪	①	②	③
69. Affectionate	⓪	①	②	③
70. Drowsy	⓪	①	②	③
71. Self-assured	⓪	①	②	③
72. Mentally alert	⓪	①	②	③

BE SURE YOU HAVE ANSWERED EVERY ITEM

PBI 022 POMS BI Copyright © 1980 EdITS/
Educational and Industrial Testing Service, San Diego, CA 92107

SCANTRON® FORM NO. T-101269-POMS 4987-C911-5 4 3 2