Chapter 9 Discussion: Auckland Blood Pressure Control Study

9.1.1 Introduction
9.1.2 Overview
9.1.3 Strengths of the study
9.1.4 Weaknesses of the study
9.2.1 General findings
9.2.2 Patterns of blood pressure changes
9.2.3 Physical activity
9.2.4 Salt restriction
9.2.5 Two interventions versus one intervention
9.2.6 Failure to achieve statistical significance at six month interview
9.2.7 Weight and alcohol
9.2.8 Lipids and pulse
9.2.9 Age and gender
9.3.1 Implications for clinicians
9.3.2 Public health implications
9.3.3 Further research
9.1.1 Introduction

This chapter discusses the results of the Auckland Blood Pressure Control Study and focuses on the two main interventions; the prescription of physical activity and salt restriction for people with hypertension treated in the community. Also discussed in this chapter are factors known to affect blood pressure such as weight change and alcohol intake. Discussion on other dietary changes and psychological changes are not included in this thesis.

9.1.2 Overview

The results of the Auckland Blood Pressure Control Study show that statistically significant reductions in systolic blood pressure can be achieved after 3 months by the prescription of physical activity and salt restriction in treated hypertensives in a community setting. Smaller reductions occurred after six months but these were not statistically different from the control group. No reduction was seen for diastolic blood pressure. These results suggest that non-pharmacological methods for reducing blood pressure can be used in addition to medication. These findings show that non-pharmacological therapies can be effective in community settings. The non-significant result in systolic blood pressure at the six month interview may be due to a lack of statistical power and contamination of the control group(s). Other influences may be due to the changes in medication among the four intervention sub-
groups (i.e. salt restriction, exercise, exercise and salt restriction and control).

The combination of salt restriction and exercise was associated with smaller blood pressure reductions than each intervention separately. This may have been due to the participants in the combined restriction and exercise group (group A), performing the interventions to a lesser degree than those in the salt restriction or exercise groups. The less than additive effect of salt restriction and physical activity on blood pressure reduction is referred to as an interaction in the remainder of this chapter. The statistical evidence for this interaction is presented in section 8.1.1. Although the study used a factorial design, the interaction between salt restriction and exercise limited the analyses of the factorial design and most of the analyses are done on the four intervention sub-groups. The presence of the interaction between exercise and salt restriction raises the issue of which non-pharmacological method should be used first and suggests that perhaps only one intervention should be attempted at any one time.

9.1.3 Strengths of the study

A major strength of this study is that it is a randomised controlled trial with blind assessment of blood pressure. Moreover the participants performed their intervention in the community and the study uses interventions which can be readily adopted in general practice. The results are therefore more generalizable to
the community than results from a laboratory based study. Although the magnitude of salt restriction was modest, statistically significant reductions in blood pressure were achieved and this is one of the few studies to demonstrate blood pressure reduction by salt restriction in a community setting. It is also one of the first community based studies to demonstrate blood pressure reduction by the prescription of physical activity.

9.1.4 Weaknesses of the study

**Methodological issues**

A weakness of this study is the influence of contamination in the control group. Contamination is a term used to describe a situation in which some of the control group perform the intervention when this was not intended. Both the study results and the anecdotal information from the participants indicated that physical activity increased and salt intake was reduced in the control groups as well as the intervention groups. This form of control group contamination will produce an underestimate of the true reduction in blood pressure from these interventions.

Co-intervention is another methodological term and is the opposite of contamination. Co-intervention occurs where the intervention group gets extra attention or a second intervention that is not intended. An example of this in the physical activity
literature occurred in a study of community based low intensity exercise compared with laboratory based moderate intensity exercise (Hagberg, 1989). In that study the moderate intensity group was seen by the study staff more frequently than the low intensity group and this is a co-intervention situation. In the Auckland Blood Pressure Control Study there is evidence of co-intervention and contamination (depending on which direction of factorial analysis in considered) in all three intervention groups and the control group. It is not possible to know how much impact such additional changes have had on the results. Co-intervention and contamination will always be an issue in community based studies of unblinded interventions. Contamination of control groups may be one of the reasons for the failure of community based salt restriction studies to show a benefit while the laboratory based studies often find a benefit. For health promotion purposes co-intervention is to be encouraged as it is desirable for the community to make multiple changes in lifestyle; for the researcher it is a problem to be circumvented. The researcher wants to know the answer to the question of how effective an intervention is before recommending it to the public. Until the answer is clear it is unwise to invest resources in health promotion programmes that may not be effective. Co-intervention can be avoided in laboratory based studies of physical activity by appropriate design and conduct although there are at least four other recent laboratory based studies in which this remained a problem (Hagberg, 1984b; Hurley, 1984; Hurley, 1989; Urata, 1987).
The most common form of co-intervention is where the intervention group receives more supervision of their physical activity and/or has their blood pressure measured more often than the control group. This can be avoided by having the same amount of attention given to the control group or alternatively performing a cross-over study thereby ensuring equal attention to both groups.

Estimates of sodium intake

The individual estimates of sodium excretion used in the Auckland Blood Pressure Control study are not optimal. It has been recommended that at least three individual measures of 24 hour urine are required to obtain a clear picture of an individual's average daily intake (Liu, 1979). The Auckland Blood Pressure Control Study obtained only one 24 hour urine sample per person, at the beginning and end of the study because of cost and the potential problem of compliance in obtaining multiple samples from community based participants. The analysis of 24 hour sodium excretion is therefore limited to the group data rather than individual data. Multiple 24 hour urine collections are regarded as ideal although very few studies achieve this. In other community based studies the number of 24 hour urine samples collected range from one, in studies from Belgium (Staesson, 1988), New Zealand (Thaler, 1982), Scotland (Smith, 1988), England (Williams, 1986) and Australia (Beard, 1992), to two in a Welsh study (Watt, 1983). The number of 24 hour urine samples, for baseline or final assessment, collected in randomized controlled studies were as
follows: one only in two Australian studies (Australian National Health and Medical Research Council Dietary Salt Study Management Committee, 1989); (Morgan, 1978); two in British studies (MacGregor, 1982); (MacGregor, 1989) and two in an Indian study (Patki, 1990). It would appear that most research studies only attempt to collect one or two samples and that our single baseline (i.e. initial) and final sample is in keeping with other studies. The recommendation that multiple urine samples are needed to assess true intake may be warranted in individual clinical cases but it is a major inconvenience for study volunteers to collect repeated samples.

In the Auckland Blood Pressure Control Study the 24 hour urine sample was collected after the baseline interview which meant that participants knew the intervention group to which they had been allocated. This may explain some of the differences in the baseline 24 hour urine values for the 4 sub-groups. These group differences in baseline 24 hour urine results provided an unexpected additional piece of information and suggested that the combined salt restriction and exercise group behaved differently from the salt restriction group. This may explain the fact that blood pressure reduction by exercise and salt restriction was not additive in the combined group (i.e. group A).

At the time of designing the study it was hoped that the salt frequency questionnaire would be as useful as the 24 hour sodium excretion. The results from the Auckland Blood Pressure Control study did not find this as the values from the salt frequency
questionnaire were not well correlated with the 24 hour urine tests. One of the developers of the questionnaire now considers that it is better used as a clinical tool to obtain a measure of sodium restriction in individuals rather than a good measure of 24 hour sodium excretion (Beard, personal communication 1992). Beard (1992) now uses the salt frequency questionnaire to monitor the reduction in sodium intake for an individual and when the questionnaire score is lower than five, a 24 hour urine test is obtained. Thus the place of the salt frequency questionnaire would seem to be as a clinical adjunct to the 24 hour urine test rather than as a replacement.

Measurement of physical activity
The lack of an accepted and accurate measure of physical activity for epidemiological studies is also a weakness in this study. In contrast to salt excretion measurement, there is no ideal measure of physical activity (Washburn, 1986). This has not been a major concern before as all previous intervention studies, examining the effect of physical activity on blood pressure, have been laboratory based. In the majority of those studies the precise level of intensity and duration of each exercise episode has been prescribed and measured by direct observation (Arroll, 1992). The intensity is usually measured as a percentage of maximal oxygen uptake, although some studies use target pulse rates. The Auckland Blood Pressure Control Study used a physical activity recall questionnaire
designed for a case-control study as there were no questionnaires designed for randomised trials of physical activity and blood pressure undertaken in a community setting (Jackson 1989). Although this questionnaire has been validated in the case-control context its use may be limited in randomised trials (Arroll, 1991c). The need for an appropriate questionnaire is discussed below in sections 9.2.3 and 9.3.3.

**Statistical power**

The baseline standard deviations in this study for the systolic blood pressure ranged from 15.8 mm Hg to 18.1 mm Hg while the range for diastolic blood pressure was from 8.8 mm Hg to 10.9 mm Hg. The statistical power calculations were based on the systolic and diastolic blood pressures from the Auckland Heart Study which were 15 mm Hg and 10 mm Hg respectively. The wider than expected range for the systolic pressure may reflect the nature of the participant population. The majority of participants in the Auckland Heart Study were not on medication while all participants in the Auckland Blood Pressure Control Study were on medication. It is more likely that the range of blood pressures would be wider in the treated group as some persons on medication will be well controlled while others are poorly controlled. This widening of the standard deviation for blood pressure after treatment has been demonstrated in the Systolic Hypertension in the Elderly Program where the standard deviation for both systolic and diastolic blood pressure increased as more persons received pharmacological
therapy (SHEP Cooperative Research Group, 1991). The failure to show a statistically significant reduction in systolic blood pressure at the six month interview may have been partly due to the lack of statistical power. The power calculation at the six month interview for systolic blood pressure, estimates the number needed would be 79 participants whereas group B had 46 participants (beta = 0.6, alpha 0.05 and a standard deviation of 17.2 mm Hg, group B (exercise only) systolic blood pressure = 133.9 and the control group (group D) systolic blood pressure = 139.1 mm Hg). This latter calculation is univariate and does not take into account the baseline differences and the repeated measures analysis.

Potential bias due to change in medication
One potential source of bias is the changes in anti-hypertensive medication and is only a "weakness" in this study as it was hoped that participants would not change their medication. Reduction in medication or cessation of medication would be the desirable outcome of a clinical intervention. In the extreme case participants in the intervention groups could be so successful in lowering their blood pressure that a decrease in medication would be achieved. This could occur either as a result of hypotensive symptoms leading to a reduction in medication or by low levels of blood pressure being detected on a regular doctor's visit and medication being lowered accordingly. Thus a very successful study could achieve reductions in medication; the reduction in medication might in turn result in an elevation in blood pressure and hence the intervention
effect would erroneously appear as a null result. The changes in medication show little discrepancy between the four subgroups apart from group A at the three month interview. This group had: the largest number of participants either stop or decrease medication; the largest fall in medication score and the largest number of participants decrease their medication in comparison with the control group. Thus the smaller than expected reduction in blood pressure may have been partly due to the respective medication changes.

**Generalizability**

Involvement of self-selected volunteers may limit the generalizability of the study findings to the wider community. It may not be possible to encourage all community treated persons with hypertension to increase their physical activity and/or decrease their salt intake. This study suggests that blood pressure reduction is possible in those who can make these changes.

9.2.1. **General findings:**

The observation that the baseline systolic blood pressure values for all four intervention groups were within 0.9 mm Hg confirms a satisfactory randomisation procedure. It is always possible in small studies for randomisation to produce differences in variables.
This may have been the case for the diastolic blood pressure. It may also reflect the greater difficulty in measuring diastolic blood pressure thereby producing less precise estimates. The 87% completion rate is high and adds to the internal validity of the results although the external validity maybe compromised by the number of participants who were volunteers. The baseline characteristics confirm that the participants are a selected subgroup of the population as only two participants were non-European, 48% had never smoked and a high proportion had tertiary education.

9.2.2. Patterns of blood pressure changes
The overall pattern for both the systolic and diastolic blood pressures (table 8.2) was a fall at the three month interview followed by a small rise at the six month interview. The fall in blood pressure in both the intervention and control groups was expected. In the Australian National Blood Pressure Study the blood pressure in the placebo group continued to fall for the first four months of the study (Management Committee of the Australian Therapeutic Trial in Mild Hypertension, 1982). This is most likely due to the loss of the alerting response or the white coat effect (Mancia, 1983). The rise in blood pressure from the three month interview to the six month interview was unexpected and there are a number of possible reasons for this. Firstly, the majority of participants had a reduction in blood pressure at the three month
abandoned the intervention(s) having seen reductions in blood pressure at the three month interview. Secondly, the three month interview occurred during the summer months of December to March and the warmer weather would have been more conducive to activities such as brisk walking. Warm ambient air temperature is also associated with lower blood pressures (Cruickshank, 1985) and blood pressure is known to be lower in the warmer months (Brennan, 1982). The study by Brennan et al (1982) was part of the Medical Research Council's treatment trial for mild hypertension. Their results showed systolic and diastolic blood pressure higher in winter than in summer. This was consistent for participants on placebo, bendrofluazide and propranolol. The range was greater for 55-64 year olds (eg 8 mm Hg for systolic and 3 mm Hg diastolic change) than for the 35 to 44 year olds (eg 6 mm Hg for systolic and 2 mm Hg diastolic change). The six month interviews in the Auckland Blood Pressure Control Group were undertaken from March to June which are the autumn and winter months in New Zealand and the cooler temperatures may account for the lower blood pressures. As changes due to temperature would affect all participants equally this would not affect the internal validity of the study.

9.2.3. Physical activity
The exercise only sub-group (group B) showed a statistically significant reduction in systolic blood pressure when compared with the control group (group D) at the three month interview but not the six month interview (Table 8.21). One of the possible reasons for the results at six months has been mentioned above (9.2.2) and relates to a possible abandoning of the behavioural changes from the three to the six month interview. While some changes could have occurred by chance the fact that this pattern
changes could have occurred by chance the fact that this pattern occurred with all of the groups suggests that a behavioural explanation is more likely. Results of a similar magnitude have been found in other studies which have shown blood pressure reductions over similar and longer periods. Other studies showing a reduction in blood pressure for longer study periods are: Hagberg, 1989 -nine month duration; (Hagberg, 1984b) -eight month duration; (Somers, 1986) -six months duration and (Seals, 1985) -six months duration. The length of time that the majority of the population can maintain behavioural changes, outside of the study setting, is an issue arising from this study.

The difference at three months in the reduction of the systolic blood pressure between the exercise group (group B) and the control group (group D) of approximately 9 mm Hg is similar to that in other randomised controlled trials. In four studies of moderate to vigorous intensity activity with similar baseline systolic blood pressures (range 136.6 to 150 mm Hg) the reductions in systolic pressure ranged from 7 mm Hg to 11 mm Hg (Somers, 1991b), (Cononie, 1991), (Martin, 1990), (Nelson, 1986). However, in the same four studies the diastolic blood pressure reduction in comparison with the control groups ranged from 6.8 mm Hg to 10.4 mm Hg which was considerably higher than that achieved in the Auckland Blood Pressure Control study. The study design that was most similar to the physical activity part of the Auckland Blood Pressure Control study was that by Seals and Reiling (1991). The age group in this study was over 50 years old with baseline blood
pressure of 148/89 and the intervention was walking for 30 minutes, three times a week. The reduction in systolic and diastolic blood pressures in the Seals and Reiling (1991) study, compared with the control group was 10 mm Hg and 3 mm Hg respectively. In the review of the literature (chapter 6) the range of diastolic blood pressures is narrower than the range of systolic blood pressures and may simply reflect the wider range of pressures available for systolic pressures. The Seals and Reiling (1991) study is the only good quality study of low intensity activity and the results for systolic blood pressure are similar to those of the Auckland Blood Pressure Control Study. The small reduction in diastolic blood pressure raises the question of the effect of intensity of activity on the relative reductions of systolic and diastolic blood pressure.

As mentioned above the physical activity questionnaire used to assess compliance with the intervention may not be the ideal way to document average exercise levels. The questionnaire asks about exercise over the previous three months and this could mean that responses at the 6 month interview are a better reflection of the activity between the three month and six month interview than at six months. This is a weakness of using a three month retrospective questionnaire. While a question about recent activity, such as activity over the previous month, could be more valid it is also important to ask about activity since the previous interview. As the blood pressure reduction of regular exercise occurs within a few days and is lost over a period of two weeks appropriate questions should relate to physical activity in the preceding weeks.
A diary was not an option as this may have disclosed the study hypothesis to the control group. In the Auckland Blood Pressure Control Study the question about last physical activity gives some insight into the most recent activity (table 8.31). The fall in the median hours since last activity for the two exercise intervention groups at the three month interview was expected and appears to follow the changes in systolic blood pressure more closely than the three month recall questionnaire.

9.2.4. Salt restriction

The failure of the combined salt restriction groups A and C to show a significant result while the salt restriction only group (i.e. group C) showed a significant difference at three months is due to the interaction effect. The 24 hour urine results for sodium excretion and salt frequency scores are similar and confirm that more salt restriction occurred in the two salt intervention groups than in the non-salt restriction groups. The differences between the two groups at baseline is due to the first urine sample being taken after the participants had been notified of the intervention.

As with the exercise only group, the salt restriction sub-group (group C), had a statistically significant reduction in systolic blood pressure when compared with the control group (group D) at the three month interview but not the six month interview. Some of the reasons for this finding have been discussed above. There was no statistically significant difference for the reduction in diastolic
blood pressure and the potential reasons for this finding are discussed in section 9.2.6.

The finding that alcohol intake was related to the sodium reduction intervention (table 8.23) could be due to a number of factors. Firstly, persons who consume large amounts of alcohol may have been poor compliers in the study. Secondly, most alcoholic beverages contain some salt and in public bars salty foods are often served to stimulate sales of alcohol. Finally, high alcohol intakes are associated with a pressor effect of their own (Puddey, 1985). A relationship between salt intake and alcohol restriction has been shown in a study by Parker et al (1990) where salt restriction was no better than alcohol restriction in a treated group of male hypertensives with a moderate to high alcohol intake.

Although the baseline results for twenty-four urine samples may be influenced by the participants knowledge of the interventions, the value for the control group (group D) is the best estimate of the true baseline value. The median value for the twenty-four hour sodium excretion at three months for salt intervention group (group C) was 101 mmol/l giving a potential reduction in 24 hour sodium of 50 mmol/l while the 6 month reduction was approximately 40 mmol/l. A recent review found a 5 to 15 mm Hg (Law - III, 1991) reduction in blood pressure for a 100 mmol reduction in sodium intake. The results from the Auckland Blood Pressure Control Study are in this range with the reduction in systolic blood pressure being 5.5. mm Hg and 3.1 mm Hg at the three and six month interviews respectively. Moreover the results show
that simple advice that could be given in a community setting can result in significant salt restriction that is accompanied by a reduction in blood pressure. This is contrast to most studies of salt restriction that provide intensive dietary counselling.

Studies of salt restriction and reduction in blood pressure have found a wide range of blood pressure reductions corresponding with a wide range of reductions in 24 hour sodium excretion (Grobbee, 1986). The community based studies are of little help in understanding this issue. The Belgian two-communities study had only a 25 mmol/day decrease in sodium excretion and no change in blood pressure (Staesson, 1988). The Welsh study had a 50 mmol/day reduction in 24 hour sodium and no reduction in blood pressure (Watt, 1983). A study using a salt restricting diet and slow sodium tablets or placebo, had a 6.1 mm Hg and 3.7 mm Hg reduction in systolic and diastolic blood pressures respectively (Australian National Health and Medical Research Council Dietary Salt Study Management Committee, 1989). This was associated with a 52 mmol/day reduction in sodium excretion; the starting systolic and diastolic blood pressures were 155.2 mm Hg and 95.1 mm Hg respectively. Double blind cross-over studies have the best design for studying salt restriction and in one of these an 8 mm Hg and 4 mm Hg reduction was achieved in systolic and diastolic blood pressure respectively (MacGregor, 1989). This was associated with a 59 mmol/day reduction in sodium excretion. The starting blood pressure in this study was 164/101 which highlights the fact that a study is more likely to show a statistically significant difference
if the mean baseline blood pressure is high (Grobbee, 1986). In a study with many features in common with the Auckland Blood Pressure Control study, Sciarrone et al (1992) achieved an 80 mmol/day reduction in sodium restriction; a significant reduction in systolic blood pressure of about 6 mm Hg and a non-significant increase of diastolic blood pressure of about 1 mm Hg. In both the studies by Sciarrone et al (1992) and MacGregor et al (1989) the participants were given salt free bread which is a major advantage in studies attempting salt restriction. This was not done in the Auckland Blood Pressure Control study as salt free bread was not available in Auckland at the time of the study. In the study by Sciarrone et al (1992) the majority of participants were on medication and there was no reduction in diastolic blood pressure; a similar finding to that in the Auckland Blood Pressure Control study. Although there is evidence that salt restriction is beneficial for patients on betablockers and diuretics and possibly not beneficial for patients on calcium channel blockers, there is no evidence in the Auckland Blood Pressure Control study to suggest this (Nicholson, 1986), (MacGregor, 1987).

9.2.5. Two interventions versus one intervention
The lack of an additive effect of salt restriction and physical activity was an unexpected result and potential reasons for this have been given above. It appears that group A (salt restriction and exercise) did not exercise nor salt restrict as much as the groups in
which this was the only intervention. Also the medication changes in Group A (salt restriction and exercise) differed from groups B (exercise only) and C (salt restriction only) and it is possible that these changes may have obscured a larger fall in blood pressure. The only other study to examine the effect of both exercise and/or salt restriction found that there was an additive effect for the salt restriction and exercise (Nomura, 1984). Unfortunately the study by Nomura et al (1984) incorrectly analysed the study by only making comparisons within the groups rather than between them. When the long run-in period is considered in this study, the exercise only group had a reduction of systolic blood pressure of 25.4 mm Hg while the exercise and salt restriction group had a 38.4 mm Hg reduction. The corresponding figures for the diastolic blood pressure were 17.4 mm Hg and 20.9 mm Hg.

There have been few studies showing that two non-pharmacological interventions are additive in lowering blood pressure (Beilin, 1991). This has implications for public health education and advice as it may be counter-productive to attempt to make more than one behavioural change at a time. One other theoretical possibility is that, in the Auckland Blood Pressure Control study, the exercise group may have lost sodium by perspiration and hence been less able to diminish their sodium intake. This is a highly unlikely hypothesis as sodium excretion is small in comparison with urinary excretion and perspiration is reduced in salt restricting situations (Beard, 1990). There are other factors which may need to be taken into account if non-
pharmacological therapy is to be appropriately targeted to individuals. In a study by Cox et al (1990) sedentary male drinkers gained no additional benefit in terms of blood pressure reduction from 30 minutes of exercycling, thrice weekly, at an intensity of 60-70% of maximal oxygen uptake. The participants in this study had consumed a minimum consumption 210 mls of alcohol per week and in men with this level of alcohol intake it may be more appropriate to initiate alcohol restriction before recommending physical activity.

9.2.6. Failure to achieve statistical significance
The absence of a statistically significant reduction in diastolic blood pressure for any of the interventions may be due to a number of reasons. Firstly, diastolic blood pressure is more difficult to measure and hence there is a potential problem with precision. Secondly, all the participants were on anti-hypertensive medication and the diastolic pressure is the measure used as the target for treatment. There may be a "floor" effect below which it is difficult for the level to be reduced. In this study it is likely that the diastolic blood pressure is closer to a theoretical floor than the systolic blood pressure as this group of patients would have had their medication titrated to their diastolic blood pressures. Difficulty in demonstrating a statistically significant reduction in diastolic blood pressure, but not systolic blood pressure, in exercise studies has been found by the author and in a study of salt
restriction and low-fat/high fibre study (Sciarrone, 1992). Finally, the baseline diastolic blood pressure for the control group D was significantly higher than the baseline diastolic blood pressures for the other three groups and therefore this group had a greater potential to fall before reaching the floor level. This may have been another factor in the failure to achieve statistical significance for the diastolic blood pressure.

The interaction effect between exercise and salt restriction is one of the reasons for the failure of the combined exercise groups (i.e. group A and group B) to show a significant result. The failure of the exercise only group (group B) to show a significant difference at six months may be due lack of statistical power and the abandoning of the intervention by some participants.

9.2.7. Weight and alcohol

Weight and alcohol intake are variables known to influence blood pressure. In this study weight changed in a manner consistent with the changes in blood pressure while alcohol showed a less consistent pattern. Under-reporting of alcohol intake is likely at all stages but may have been more marked at the baseline interview as a result of lack of familiarity with the study setting and study staff.

The reduction in weight for the three intervention groups at the three month interview (table 8.32) and the increase recorded in the control group is not unexpected as in an unblinded intervention
study other factors, such as weight, will also change. The weight loss in the combined exercise groups at the three month interview, in contrast with the no exercise group, may have been a consequence of the increase in their physical activity. While there is general agreement that weight loss is the most effective non-pharmacological means of lowering blood pressure (Langford, 1989) it is standard advice to recommend exercise as an adjunct to calorie restriction and there is evidence that physical activity enhances weight loss (The Trials of Prevention of Hypertension Collaborative Research Group, 1990). Weight loss is not an inevitable outcome of all physical activities as weight gain in the presence of blood pressure reduction has been demonstrated in studies of circuit weight training ((Hagberg, 1984a), (Harris, 1987), (Hurley, 1988), (Hurley, 1984)). These findings raise questions about the relationship between changes in body weight and physical activity.

9.2.8. Lipids and pulse

None of the changes in the lipids were statistically significant and only the rise in the triglyceride level for group A at the six month interview was unexpected. The triglycerides were not measured in the fasting state and apart from this there is no theoretical explanation for this finding and it may be a chance variation. The small rise in high density lipoprotein cholesterol in the two exercising groups could have been predicted as these levels are
raised by physical activity (Chandrashekhar, 1991). This is an additional form of validation and suggests that the two exercise groups did in fact exercise more than the other groups. Other factors such as alcohol intake may have had an impact on lipids although the results suggest that the two exercise groups consumed less alcohol than the non-exercising groups.

The absence of any pattern of change in pulse rate may be due to the pulse rate being measured for 10 seconds and multiplied by 6 to obtain a beats per minute estimate. While this is a reasonable approach in a clinical setting it lacks the precision for a research study and has almost certainly resulted in a loss of information.

9.2.9. Age and gender
The absence of any difference in blood pressure reduction from physical activity for the younger and older participants is an interesting finding as a review of salt and hypertension found greater benefits for older persons (Laws III, 1991).

Although there were some gender differences in blood pressure reduction there was no clear pattern. While men appeared to have a greater fall in systolic blood pressure than women at the three month interview, women had a greater fall in diastolic blood pressure at the six month interview. These results are difficult to interpret especially as the study was not designed to examine gender differences.
9.3.1. Implications for clinicians

The key place for non-pharmacological therapy is in the initial treatment for mild hypertension. It can often be initiated as soon as an elevated blood pressure has been measured without waiting for the standard three separate measures to confirm the diagnosis. This is because many persons in western society need to make some changes in their lifestyle and an elevated blood pressure can facilitate discussion of these issues. The non-drug treatment of mild hypertension is also important from the economic point of view as the cost-effectiveness of drug treatment for persons with diastolic blood pressures of 90 mm Hg is much lower than for persons with diastolic blood pressure of 110 mm Hg (Kawachi, 1990). For young men at the lower levels of mild hypertension the effect of drug treatment can result in negative quality adjusted life years because the side effects outweigh the benefits.

The fact that a reduction in systolic blood pressure was found in the Auckland Blood Pressure Control study at the three month interview for both the exercise only and salt restriction only groups should encourage clinicians to attempt these interventions in their patients on medication. The intervention required only simple verbal advice and written information which should make this an attractive intervention in the general practice setting. The baseline data from the Auckland Blood Pressure Control Study found that the majority of patients reported not having had any advice on
non-pharmacological methods of lowering blood pressure. Doctors may focus their advice on those patients who have mildly elevated blood pressure but not those high enough to warrant pharmacological treatment. Our sample may have therefore been biased by the participants being on medication and hence less likely to have received non-pharmacological advice.

Recommendations for treating mildly elevated hypertension with non-pharmacological therapy before pharmacological therapy have been published (Canadian Consensus Conference on Non-pharmacological approaches to the management of high blood pressure, 1990); (Research Unit, South Australian Faculty, Royal Australian College of General Practitioners, 1990), (Silverberg, 1990). Recommendations for non-pharmacological therapy for those already on medication has received less attention in spite of evidence that less medication is needed for treating hypertension in salt restricting persons. Even less attention is given to preventing hypertension by lifestyle change in spite of the evidence that this is possible (Stamler, 1989). It is possible that clinicians are not convinced of the effectiveness of adopting non-pharmacological therapies to lower blood pressure. This is certainly the author’s anecdotal experience. The fact that no non-pharmacological therapy has been studied long enough to assess cardiovascular end-points is a valid criticism.

There are numerous health promotion reasons for suggesting non-pharmacological therapy for hypertension. The ultimate goal is the reduction of the cardiovascular morbidity and mortality, not
blood pressure reduction, which can be achieved by medication (Beilin, 1991). This is important for the prevention of coronary heart disease as evidence to date suggests that only small reductions in coronary heart disease are obtained from pharmacological therapy of high blood pressure (Collins, 1990). Non-pharmacological therapies such as weight reduction have benefits over medication in that they are "permanent" i.e. the blood pressure reduction that accompanies them do not vanish with a missed dose of an antihypertensive tablet. Lifestyle changes such as a low salt diet can also have an impact on other members of a family who, knowingly or unknowingly can adopt a low salt diet if the food preparers make low salt meals.

Physical activity is of benefit to persons not on medication and the results of the Auckland Blood Pressure Control study show that physical activity benefits hypertensives on medication. It is also encouraging that low intensity activity such as brisk walking appears to be effective in lowering blood pressure. This is consistent with unpublished work by the author and with other work on low intensity activity in this field (Seals, 1991), (Arroll, 1992). Brisk walking has the advantage of being acceptable to older persons who can expect great benefit from the lowering of their blood pressure (SHEP Cooperative Research Group, 1991). Also there is less danger of musculoskeletal injury with low intensity activity compared with high intensity activity.

The results of the Auckland Blood Pressure Control Study suggest that physical activity prescribed three times a week is
blood pressure reduction, which can be achieved by medication (Beilin, 1991). This is important for the prevention of coronary heart disease as evidence to date suggests that only small reductions in coronary heart disease are obtained from pharmacological therapy for this condition (Collins, 1990). Non-pharmacological therapies such as weight reduction have benefits over medication in that they are "permanent" i.e. the blood pressure reduction that accompanies them do not vanish with a missed dose of an antihypertensive tablet. Lifestyle changes such as a low salt diet can also have an impact on other members of a family who, knowingly or unknowingly can adopt a low salt diet if the food preparers make low salt meals.

Physical activity is of benefit to persons not on medication and the results of the Auckland Blood Pressure Control study show that physical activity benefits hypertensives on medication. It is also encouraging that low intensity activity such as brisk walking appears to be effective in lowering blood pressure. This is consistent with unpublished work by the author and with other work on low intensity activity in this field (Seals, 1991), (Arroll, 1992). Brisk walking has the advantage of being acceptable to older persons who can expect great benefit from the lowering of their blood pressure (SHEP Cooperative Research Group, 1991). Also there is less danger of musculoskeletal injury with low intensity activity compared with high intensity activity.

The results of the Auckland Blood Pressure Control Study suggest that physical activity prescribed three times a week is
sufficient to lower systolic blood pressure. The treatment of systolic blood pressure has assumed greater importance with the publication of new findings (SHEP Cooperative Research Group, 1991). The importance of systolic blood pressure as a better predictor of vessel damage has been known for some time as the Framingham data have shown that systolic, but not diastolic blood pressure, is the independent predictor of cardiovascular events (Kannel, 1976). Systolic pressure is also more important in terms of engineering fluid dynamics as oxygen supply is best predicted by the maximum rather than the average pressure (Hoffman, 1978).

The results of the Auckland Blood Pressure Control Study should also encourage clinicians to initiate salt restriction as a means of lowering blood pressure. The advice given was simple and did not require intensive input from a dietitian. Most persons are quite unaware of the high salt intake of processed foods such as Kellogg's cornflakes. A low salt food is one where the sodium content is below 120 mg/100gm; Kellogg's Cornflakes and Kellogg's Rice bubbles have sodium contents of 1044 and 1093 mg/100gm respectively. In contrast Weet Bix has a content of 270 mg/100gm and Kellogg's Puffed Wheat 3 mg/100gm (Salt Skip Incorporated and the Australian Nutrition foundation for the National Better Health Program, 1990). A major hurdle to instituting an individual programme of sodium restriction is the advice that multiple 24 hour urine samples are required to obtain an accurate sodium intake (Liu, 1979). Obtaining a 24 hour urine sample is quite demanding for individuals and there are alternatives to this. In the Salt Skip
programme in Tasmania the salt frequency checklist is used until a score of 5 is obtained and at that point a 24 hour urine sample is obtained (Beard, personal communication 1992). An alternative to this is to use overnight urine samples which will give an estimate of the 24 hour excretion (Dela, 1979), (Luft, 1982), (Kawano, 1990). There has been much debate over ensuring the adequacy of 24 hour urine samples with creatinine levels not being a reliable measure of validity (Beard, 1990). There are ways of checking this by giving p-aminobenzoic acid tablets orally and measuring the urinary output of this substance (Williams, 1986). This latter manoeuvre would only be feasible in a research setting.

Evidence from other studies are quite convincing in the reduction achieved by sodium restriction (Law Ill, 1991). The results of the Auckland Blood Pressure Control Study which suggest that general practitioners do not think that salt restriction is a worthwhile intervention is consistent with the anecdotal experience of the author. This maybe due to the difficulty in motivating patients, the limited availability of low salt foods and the relative ease of the alternative strategy of prescribing medication. Greater emphasis on the value of salt restriction as a non-pharmacological therapy for hypertension is needed at the post-graduate training level.

The fact that neither the Auckland Blood Pressure Control Study nor many other studies have found an additive effect for two non-pharmacological methods for lowering blood pressure means that clinicians will need to choose the method with which to begin
therapy. Although a first choice for non-pharmacological therapy has not been researched, as a clinical decision it is logical to encourage the overweight to lose weight; the inactive to exercise; the heavy drinkers to decrease their intake and those with a high salt intake to reduce sodium containing foods. These non-pharmacological approaches to lowering blood pressure will not work for everyone with hypertension and for some persons medication will be necessary. The traditional advice of informing patients that medication will be needed for the rest of their lives is no longer valid as it is possible to successfully stop medication in significant proportions of people who have been on medication (Schmieder, 1991). The duration of successful medication withdrawal is less certain and some persons will need to restart medication. For those persons already on medication the results of the Auckland Blood Pressure Control Study show that further reductions in blood pressure can be achieved by exercise and salt restriction.

The quote "hypertension is neither essential nor inevitable in acculturated societies" encourages us to see essential hypertension as a preventable disorder of known aetiology for which much can be done in terms of control and prevention (Beilin, 1988). While the results of the experimental studies show that non-pharmacological therapy can be successful, the observation that doctors are less willing to prescribe these therapies than patients are to adopt them is disappointing. One of the challenges for clinicians will be to find ways of motivating their patients to make changes and to maintain
those changes for long periods of time. Further research on this issue is required in the community setting. Advising patients that it can take up to four weeks to adapt to a low salt diet will be important in assisting individuals to lower their sodium intake. Recent increases in the cost of prescription medication to patients in New Zealand may encourage both doctors and patients to consider non-pharmacological therapies for blood pressure.

9.3.2. Public health implications

The need to encourage the population to increase physical activity has resulted from the sedentary nature of most modern occupations. Unfortunately a population approach for physical activity requires that individuals change their behaviour. This is not the case for children where physical activity can be promoted at school thereby achieving a population approach. The need for people to be more active is receiving attention in the medical media as shown by a recent leading article in the British Medical Journal (Gloag, 1992).

The review in chapter 6 found the diastolic blood pressure reductions achieved by exercise averaged 6 mm Hg. A meta-analysis by Collins et al (1990) found that pharmacological therapy had resulted in an average 5 mm Hg reduction in blood pressure which translates into a 34% reduction in stroke and a 21% reduction in coronary heart disease. If sustained physical activity is possible on a population basis then significant health benefits are possible from the subsequent blood pressure reductions. Physical activity
has the additional benefit of raising high density lipoprotein cholesterol which could have benefits in terms of coronary heart disease over and above the benefits of blood pressure reduction.

In the past the addition of salt to food has been necessary as a preservative but with the advent of cheap refrigeration this is no longer the case. Many of the foods that once needed sodium to remain fresh, such as cheese and bacon, have become entrenched in the western diet. Cooking with salt contributes up to 15% of the adult salt intake. More than 75% of sodium intake comes from sodium added in the processing phase with the remainder being from the natural sodium content of foods (Beard, 1990). While salt added to food in the processing phase is a hazard to health, this situation lends itself to the potential for mass reduction in sodium intake by encouraging manufacturers to produce low salt products. A reduction in salt added to processed foods would facilitate a population approach to blood pressure reduction. The reduction in blood pressure with salt restriction ranges from diastolic blood pressures of 5 to 15 mm Hg, depending on age (Law III, 1991).

There have been no studies of the impact of non-pharmacological antihypertensive therapies on cardiovascular endpoints. It may never be possible to conduct such a study as it would be difficult to avoid contamination of the control group and in a society where pharmacological therapy is the norm the logistical and ethical issues may be insurmountable.

The National Better Health Program has set a target for sodium intake of 100 mmol/day for universal adoption in Australia
by the year 2000 (Beard, 1990). The New Zealand Health Goals and Targets recommended a target of 140 mmol/l by 1995 and 120 mmol/l by the year 2000 (Department of Health, 1989). The Auckland Blood Pressure Control study is the most recent study in New Zealand to examine 24 hour urine for sodium excretion. It would be expected that the participants in this study would be more likely than the average New Zealander to be on a low salt diet as a result of their have receiving medication for hypertension. The mean 24 hour urine sodium value for the control group (group D) for men and women was 168.2 mmol/day and 127.1 mmol/day respectively and was not much different from the results of a 1981 New Zealand community based study (Simpson, 1982). The mean values for men and women in that study were 172 mmol/day and 134 mmol/day respectively and these were no different from the results from the same town in 1978. These facts suggest that there has been little or no change in the salt intake of the average New Zealander and there appears to be no concerted public health effort aimed at reducing salt intake in spite of sodium reduction being one of the New Zealand Health Goals and Targets (Department of Health, 1989).

The availability of low or no-salt bread will be a key factor in lowering the sodium intake of the population. Salt-free bread is not widely available in New Zealand although some small bakeries do make it and other bakeries do so on request. At the time of the study the lowest sodium content in bread was 250 mg/100 gm in the Naturlich brand while others had up to 3 times this level. Since
the study was completed this brand had stopped printing the food component amounts on the packet. This highlights the problem for New Zealand consumers in assessing the contents of commercially prepared foods. Food labelling will be a key step in the population and individual approach to sodium intake reduction.

There are two common concerns expressed about the reduction of sodium intake. Firstly, there is concern that a reduction in iodine intake will occur if the intake of sodium is reduced. New and unplanned sources of iodine intake have occurred since goitre was endemic. These include added iodine to milk as a result of the use of iodine compounds to clean dairy equipment and adding potassium iodate to bread as a bread improver (Beard, 1990). The issue of heat stroke is also no longer the concern that it has been in past, as it is no longer believed to be caused by a low salt intake. The Israeli army stopped issuing salt tablets in 1967 and no cases were reported in 21 years of follow up (Beard, 1990).

9.3.3. Further research
Reviews of physical activity and blood pressure reduction highlighted the issues of the poor quality of the literature and the gaps in the research (Arroll, 1992), (Seals, 1984), (Dwyer, 1983). Although a number of studies have involved women none of the analyses have been done by gender. As women have lower rates of coronary artery disease the effect of physical activity on blood
pressure in women requires elaboration. A well designed study examining the effect of differing levels of intensity of a single mode of activity on resting post-exercise blood pressure is needed. The available evidence is poor but suggests that low level activity is as good if not better than high intensity activity.

More studies of combined interventions are also needed. There have been some interesting findings from other factorial designed studies. The study by Cox et al (1990) showed that, in men with moderate alcohol intake, exercise had no additional benefit on blood pressure. In another factorial study salt restriction had no additional benefit over alcohol restriction (Parker, 1990). These findings require future research to examine factors in combination rather than in isolation. Another strategy could be to study the effect of letting the participants choose the order in which they attempt non-pharmacological therapy rather than by external prescription. For example, an overweight sedentary person with a high salt intake may prefer to increase activity as the first step in non-pharmacological therapy for high blood pressure. Having achieved some success, in at least attempting the behaviour change, may make them amenable to other lifestyle changes.

There are no published data on the duration of an exercise episode required to lower blood pressure in the habitually active. An unpublished study by the author using a cross-over single blind study of 10 minutes versus 40 minutes of exercise at 50% of maximal oxygen uptake found that 40 minutes was significantly better at lowering blood pressure. Another study looked at the time
course of the antihypertensive and autonomic effects of regular endurance exercise (Meredith, 1990) and found that blood pressure was reduced after the third exercise period in a programme of 40 minutes of bicycle exercise, three times per week at 60-70% of maximum work. This study also found that the blood pressure remained reduced after cessation of exercise for 2 weeks. A useful extension of this study would be to investigate the effect of three episodes of exercise on consecutive days.

Few studies have been able to document an additive effect of two separate non-pharmacological methods and this includes the Auckland Blood Pressure Control Study (Beilin, 1991). There are studies which have been successful with combined interventions such as exercise and weight loss but this does not allow the contribution of each non-pharmacological intervention to be assessed (The TOPH Collaborative Research Group, 1990). There are a number of possible reasons for this. Firstly, the baseline blood pressure may need to be very high in order to have the latitude to show a fall of 20 mm Hg (i.e. twice the 10 mm Hg for each group) for diastolic blood pressure. The loss of alerting response combined with a regression to the mean effect may require a baseline diastolic blood pressure to be higher than 120 mm Hg. This would raise ethical questions since obtaining a suitable sample would necessitate the stopping of medication. Secondly, there may be floor effect in a population beyond which it is not possible to lower blood pressure. A population such as New Zealand could lower its blood pressure to 100/70 but this would require substantial
changes in diet, body mass index and physical activity. This is unlikely to occur in a sedentary population with ready access to alcohol and food with a high salt and fat content. Finally, there may be a common final pathway by which all non-pharmacological therapies act.

Future research needs to contend with the issues of contamination and co-intervention. As studies of physical activity can only be single blinded, cross-over or latin square methods are a means of controlling for these biases. Such studies are very demanding for participants; in one latin square study participants had to attend an exercise laboratory three and seven times a week for three months (Jennings, 1986). It is not surprising that only twelve participants were in the study. Such small numbers demonstrate the power of a cross-over study to produce statistically significant results with only twelve participants. Latin square design studies could be done in a community setting with visits for blood pressure checks being the only essential inconvenience for the participants. The loss of precision, that would result from the absence of direct measurement of time and intensity, could be compensated through larger sample sizes. For example, it would be possible to have a group of persons randomised into four groups doing 10, 20, 30 and 40 minutes of brisk walking daily in a latin square model. There would be no difficulty with washout periods if each group performed the intervention for 3 weeks with blood pressure measured at the end of three weeks as the outcome.
The mechanism of blood pressure reduction needs further elucidation. Both studies of two levels of intensity found that cardiac output increased while peripheral vascular resistance decreased for high intensity activities while the reverse occurred for the lower intensities (Hagberg, 1989), (Matsusaki, 1992). However, both of these studies had methodological flaws and the definitive answer will require another study.

A validated exercise questionnaire suitable for community based trials will be needed if more research is to be done in community settings. The questionnaire used in the Auckland Blood Pressure control Study was validated in the population in which it had been used and was adequate for the case-control study for which it was designed. For randomised trials of physical activity in the community a three month retrospective questionnaire will not be sufficient and was probably not sufficient in the Auckland Blood Pressure Control study. A daily diary would be sufficient for short duration studies but for longer studies would be onerous for the participants. Suggestions for a questionnaire appropriate for a community trial is described in section 9.3.3.

The Auckland Blood Pressure Control Study has shown that both salt restriction and exercise can achieve short term lowering of blood pressure levels in the community. The challenge will be to develop strategies that encourage persons with high blood pressure to initiate changes in their lifestyle and to maintain the changes. This will require collaboration with "behavioural scientists, educational psychologists .......using different experimental models
to achieve behavioural change." (Beilin, 1991). The results of The Auckland Blood Pressure Control Study also shows that apart from weight loss, doctors give minimal advice on non-pharmacological therapy. The fact that salt restriction has been initiated by a significant proportion of patients is encouraging. However there is a need to find out why doctors are not recommending these therapies more frequently. It may be that they believe them to be ineffective or that it is difficult to both initiate and maintain behavioural changes. It may simply be that there is not enough readily available information for general practitioners.

Public health advocacy will be needed if a population approach is to be successful. The labelling of food with details of the contents and the encouraging of legislation to decrease the amount of sodium in food will be essential steps.

In summary, the current knowledge base suggests that both sodium restriction and physical activity can lower blood pressure. Future research is needed to ascertain how effective each of these interventions is in conjunction with other therapies. The episode duration and the intensity of physical activity required to lower blood pressure are still to be determined and the best methodology will be cross-over design studies. Techniques for initiating and maintaining behavioural change will be necessary if the true potential of non-pharmacological therapies is to be achieved.
Chapter 10 Conclusion:

10.1.1 Introduction
10.1.2 Auckland Heart Study Validation Project
10.1.3 Auckland Blood Pressure Control Study
Chapter 10 Conclusion:

10.1.1 Introduction

This chapter presents the conclusions for both the Auckland Heart Study Validation Project and the Auckland Blood Pressure Control Study.

10.1.2 Auckland Heart Study Validation Project

The three month physical activity recall questionnaire used in the Auckland Heart Study achieved reasonable agreement when compared with a seven day diary of physical activity. The observed correlations are likely to represent the lower limit of the true association. This could be due to random error and the fact that the three month recall asked about regular exercise on a two weekly basis which may have been missed in the seven day diary. The results were similar to those from other studies which have used a variety of gold standards. The use of total calorie intake from the food intake section of the diary as a gold standard provides an additional estimate of the validity of the questionnaire. The use of the community based sample for the validation study is a strength of this study. The validation process means that the physical activity questionnaire was truly measuring physical activity. This
in turn gives greater veracity to the findings on physical activity and coronary heart disease in the original Auckland Heart Study.

10.1.3 Auckland Blood Pressure Control Study

The results of the Auckland Blood Pressure Control Study show that statistically significant reductions in systolic blood pressure can be achieved after 3 months by the prescription of physical activity and salt restriction in treated hypertensives in a community setting. The smaller and non-significant reductions which occurred after six months may be an artefact of the research or an index of the difficulty in maintaining lifestyle changes for extended periods of time. The lack of a significant reduction in diastolic blood pressure was unexpected and may have been influenced by all the participants being on medication. The findings suggest that non-pharmacological methods for reducing blood pressure can be used in addition to medication. The prescription of physical activity and salt restriction can be successful in a community setting.

The fact that the salt restriction and exercise interventions were more successful when prescribed alone rather than in combination raises new questions. For the clinician it may more effective to prescribe only one non-pharmacological therapy at a time especially as no other studies of two non-pharmacological therapies have demonstrated an additive effect.
The randomised controlled trial design of the study, incorporating blind assessment of blood pressure, is a strength of the study. This an important issue as the majority of studies of physical activity, as a means of lowering blood pressure, are poorly designed. In spite of the design strengths of this study, contamination of the controls is an inevitable problem for interventions such as physical activity which cannot be blinded. Other factors such as changes in medication are additional difficulties in community based studies. The fact that significant changes in systolic blood pressure could be achieved in a community setting with minimal advice and supervision is encouraging for clinicians.

The results for the physical activity aspect of the study show that regular brisk walking is sufficient to lower blood pressure. These results are consistent with other studies. Although the physical activity questionnaire was valid and appropriate for the case-control study for which it was designed it may have been too insensitive for the Auckland Blood Pressure Control study. Future community based intervention trials will require more appropriate questionnaires.

The findings from the salt intervention show that blood pressure reductions can be achieved in community settings with minimal advice. Although the reductions were modest compared with some of the more supervised studies, the reductions in blood pressure and sodium excretion were consistent with other studies. As well as an effective individual intervention, salt restriction
also has potential for a population approach through the lowering the salt content of processed foods.

The physical activity results of the Auckland Blood Pressure Control study are consistent with the literature. A review of physical activity found that exercise has an independent capacity to lower blood pressure and that all activities, including weight training, are effective. The clinical trial evidence for salt restriction as a means of lowering blood pressure is fairly conclusive but the results from community studies have been poor. Other lifestyle factors need consideration as one study showed that salt restriction was ineffective in men with moderate alcohol intakes.

Future research is needed to clarify some of the remaining questions on physical activity. These include the optimal duration of exercise episodes, the intensity of exercise required to lower blood pressure and the mechanism by which blood pressure is lowered. More research on the changes in hemodynamics at different levels of intensity is needed, especially in the elderly. The evidence for the value of salt restriction has been more thoroughly evaluated. Much of the future research for both salt restriction and the prescription of physical activity will focus on motivating participants to adopt and maintain the necessary changes in lifestyle. Such research will require collaboration of medical researchers with behavioural and social scientists.
References


Arroll B, Jackson R, Beaglehole R. Validation of a three month physical activity recall with a 7 day physical activity and food intake diary. Epidemiology 1991(c);2:296-9.


Baghurst KI, Baghurst P. The measurement of usual dietary intake in individuals and groups. Transactions of the Menzies Foundation 1981; 3:139-60

Beard TC. Personal communication 1990.

Beard TC. Personal communication 1992.


Department of Clinical Epidemiology and Biostatistics, McMaster University. Hamilton Ont. Clinical disagreement II. How to avoid it and how to learn from one's mistakes. Can Med Assoc J 1980;123:613-7.


Department of Health (figures for Pharmaceuticals) Wellington; March 31 1988.

Department of Health. New Zealand Health goals and targets 1989; Wellington


National Heart Foundation of New Zealand. Exercise and Your Heart. pamphlet NHF no 48a/1988.


Rosenman RH, Friedman M. Association of specific behaviour pattern in women with mood and cardiovascular findings. Circulation 1961;14:1173-84.


SHEP Cooperative Research Group. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic


Simpson FO. Personal communication 1991.


Squires I. Primedca study: Department of Community Health, Christchurch Clinical School of Medicine, August 1983.


