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Impact of physical activity levels on infant measures and maternal health

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Abstract

Five hundred and four pregnant women participated in this study. The objective was to examine the association between selected sociocultural characteristics and physical activity on the course of pregnancy, labor, delivery infant measures and maternal health. The participants were from the European (71%), Maori (20%) and Pacific communities (9%) in New Zealand. On average, pregnant women spent 20 hours each day in sedentary activities, such as sleeping, sitting, and standing. Urban women were found to be more sedentary than rural women. There was no difference in the activity patterns by ethnicity. During the seventh month of pregnancy the low income group and beneficiaries were found to be more sedentary than others.

The need for some birth interventions was found to increase with time spent in sedentary activity. Sedentary activity was significantly related to the need for an episiotomy. The results also showed that the more active the women the lesser the need for pain relief. The need for syntocin and epidural anesthesia almost halved as the number of minutes spent in moderate high activity increased. The more the number of minutes spent in sedentary activity in the seventh month, the longer the duration of labor. However, the duration of sleeping was associated with a shorter duration of labor.

Duration of physical activity did not affect birth weight, but time spent in sedentary activity was found to impact on the gestational age of the baby. The more sedentary mothers had a shorter gestational term and the more active the subjects the more likely they were to go full term. Sedentary activity during pregnancy was found to affect weight gain between the fourth to seventh months of pregnancy. The more time women spent on moderate low to moderate high activity, the less was the weight gain. Thus standing and sitting were not beneficial for a good pregnancy outcome. It was very clear that pregnant women would need to get more active. Furthermore, physical activity during pregnancy did not affect post partum weight retention. There may be other lifestyle characteristics

such as diet both during and after pregnancy, or change in activity patterns postpartum that may have affected post partum weight retention.

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Introduction

Pregnancy is a time in a woman's life when her body undergoes many changes. Although routine lifestyle patterns are affected, healthy pregnant women continue to engage in extensive physical activity. This includes the physical demands associated with continued daily work activities. The extreme can be heavy manual labor, especially in rural areas. In addition, there are a growing number of women who continue their leisure time and sport activities throughout their period of pregnancy.

In a woman's life cycle most of the weight gain and weight retention occurs during the childbearing period. Excessive weight gain can be detrimental to the mother and the infant. The obese gravida is at an increased risk of developing gestational diabetes, pregnancy-induced hypertension, and fetal growth restriction and cesarean delivery. The positive energy balance necessary for weight gain may be achieved by an increase in energy intake. This relationship, however, can be modified by a decrease or increase in physical activity, an increase in work efficiency, changes in basal metabolism, an increase in efficiency with which energy is used to synthesize new tissue, or some combination of these factors.

Exercise is recognized as an important lifestyle factor necessary for the prevention of excessive weight gain and also for the treatment of a variety of diseases. The benefits of exercise are manifold, so some women continue to exercise even throughout pregnancy. However, traditionally and due to cultural beliefs most women may discontinue exercise during pregnancy for fear of a miscarriage and poor pregnancy outcome.

The reasons for this are varied and there is concern that the thermal, cardiovascular, metabolic and biophysical changes, which accompany physical activity, may have unfavorable pregnancy outcomes. Some research in animals and humans has shown that exercise and physical work during pregnancy is a predisposing factor to premature labor, low birth weight babies and increased infant mortality rates. Moreover, in animal studies the adverse effects of exercise during pregnancy and lactation include irreversible growth retardation with inter-generational effects in rats. Recommending physical activity in pregnancy, is therefore, done with caution and moderation is advised.

On the other hand several other studies have shown that continuing to exercise at intensities of 60% of maximum aerobic capacity does not impair fetal well-being and has maternal benefits. The reasons for this include a reduction in the magnitude of the potentially harmful responses. Despite much research, the question of whether women should exercise during pregnancy remains controversial. Moreover, in New Zealand there have been very few studies on physical activity during pregnancy and its impact on maternal health, the birth process and infant measures, in the main ethnic groups. Thus this study has been undertaken. A review of the relevant literature is presented in the following chapter.

1.1 Pregnancy and weight gain

Cross sectional studies have shown a positive relationship between body weight and parity (1). In a longitudinal 5-year follow-up study conducted to study the association between pregnancy and persistent changes in adiposity, it was found that women gained weight and body fat usually after the first pregnancy and that these changes were persistent (1). As compared to the prepregnancy body weight, Ohlin et al found a mean increase of 0.5 kg 1year postpartum in the study, but 14% of the subjects gained more than 5 kg or more (2).

The prevalence of morbid obesity is increasing steadily among women of reproductive age and the proportion of overweight women in the age group 20-39 years is between 20 and 35%(3). Obesity in later years has been associated with weight gain in early adulthood (1). One of the components contributing to this weight gain is weight retention following pregnancy. Obesity is harmful to the mother and has been associated with poor perinatal and neonatal outcomes (4). Several studies report an increased incidence of gestational diabetes, pregnancy-induced hypertension, fetal growth restriction, increased risk of cesarean births and postoperative morbidity in the morbidly obese gravida (5,6,7,8,9,10). Heredity plays a very important role in the development of obesity. Moreover, the interaction of environmental factors such as food intake, physical activity levels and smoking also affect the development of obesity (11). In those with a genetic predisposition to developing obesity, a high fat diet and a sedentary lifestyle, have an obesity promoting effect (11). 'The Stockholm Pregnancy and Weight Development Study' conducted to identify risk factors for postpartum weight retention such as dietary habits, physical activity and socio-demographic factors, reported that women who increased their energy intake during and after pregnancy, or increased their snack eating after pregnancy to 3 or more snacks/day, and decreased their lunch frequency starting during or after the pregnancy, had greater weight retention one year postpartum (11). Women who had retained 5 kg or more 1-year postpartum, were more seldom physically active in their leisure time throughout the study period compared with women with a smaller weight gain (11).

Underweight is equally not beneficial to the pregnant gravida. A pre-pregnancy weight of less than 54kg has been associated with a relative risk of 1.25 for delivering preterm (12). A review examining the relationship between gestational weight gain and preterm delivery reported that of the thirteen studies reviewed eleven showed a positive association between maternal weight gain and risk of preterm delivery (13). Moreover, studies examining pattern of weight gain noted that a low rate of gain during the latter part of pregnancy was associated with an increased risk of preterm delivery of approximately 50-100% (13,14). Reduced pregnancy weight gain in women who were poorly nourished in early pregnancy has been found to be associated with higher blood pressure in their offspring (15). Thus maternal nutritional status both before and during pregnancy is an important determinant of birth outcomes.

The Institute of Medicine (14), therefore recommends that underweight women (BMI < 19.8) should gain between 12-18kg, normal weight women (BMI 19.9-26.0) should gain between 11.5-16kg, and overweight women (BMI > 26.0-29.0) should gain between 7-11.5kg and not more than 7kg for obese women (BMI > 29.0) (16). This rate of weight gain will minimize fat gain in the obese women and maximize fat gain in the underweight women. A cohort study of 196 pregnant women found that a majority of women do not gain as recommended during pregnancy (16). Thirty-nine percent gained more than recommended and 26% gained less than recommended.

In order to minimize fat gain in pregnancy most women continue to exercise in pregnancy. Almost 10% of Australian women of childbearing age perform vigorous exercise (17). Prescribing exercise during pregnancy is done with caution, as there is concern that its physiological effects may have an adverse impact on pregnancy outcome. Some of the concerns are discussed below.

1.2 Physiological effects of pregnancy

Pregnancy is associated with alterations in body structure, metabolism, and cardiovascular and endocrine function (18,19). As a result of these changes, there are large increases in blood volume, cardiac output, and vascular conductance in association with a decrease in arterial pressure and suppression in the vascular tone. Blood flow to the reproductive tract increases 10-fold, and there is a substantial increase in the flow through the cutaneous and renal circulation (20). There is an increase in the rate of metabolism, minute ventilation, and the respiratory exchange ratio as well as insulin resistance (21). These changes along with increased hepatic and renal clearance and the increased contribution of peptides and steroids from the placenta bring about an alteration in the blood levels of most circulating hormones, substrates and catabolites (19,21).

1.2.1 Cardiovascular system

In the first trimester of pregnancy cardiac output during rest increases, and reaches a maximum of about 40% above the non-pregnant value in the second trimester, and then remains stable (22,23). This increase in cardiac output is due to an increase in both stroke volume and heart rate. The increased cardiac output is not uniformly distributed throughout the mother's body. Hepatic and cerebral blood flow remains unchanged, while blood flow to the uterus is increased. Renal blood flow is increased throughout pregnancy and especially during early pregnancy (23). The increase in red cell volume is relatively less and so hemodilution occurs. The arteriovenous oxygen difference decreases in early pregnancy, but near term it approaches the non-pregnant value. Systolic blood pressure is relatively stable throughout pregnancy (23). Diastolic blood pressure falls; being lowest at mid-pregnancy, and then tends to reach non-pregnant value by term. Both hormonal changes and the added uteroplacental circulation may elevate stroke volume and cardiac output in pregnant women (24).

1.2.2 Respiratory system

The size and shape of the thoracic cage change due to the elevated diaphragm as well as the widened transverse diameter of the thorax that develops with advancing pregnancy (24,25). Expiratory reserve volume and functional residual capacity progressively decrease during the second half of pregnancy. However, vital capacity remains essentially normal, since inspiratory capacity increases slightly. Minute ventilation increases by approximately 50%, i.e. to an extent far in excess of the need for gas exchange (24). Thus, the volume of gas for each liter of oxygen consumed (ventilatory equivalent) is higher throughout pregnancy. This is caused by increased tidal volume since respiratory frequency remains unchanged. This hyperventilation leads to a fall in arterial pCO2 to about 30mm Hg in late pregnancy. However, blood pH remains normal or is only slightly alkaline due to the increased renal excretion of bicarbonate.

Minute ventilation in pregnant women is higher than in non-pregnant control women during cycle and treadmill exercise (26). In addition, alveolar ventilation during exercise was higher in pregnant than in postpartum subjects only during the second half of pregnancy. The ventilatory equivalent, which is already increased at rest, did not change during exercise. The increase in respiratory frequency in response to a given exercise task during pregnancy has been repeatedly shown to be no different from that observed postpartum. Thus the rise in minute ventilation in exercising pregnant women is due to a rise in tidal volume. The rate of change in minute ventilation at the onset of exercise is greater than normal during pregnancy. The more rapid approach to the steady-state ventilatory response is already evident in the first 10 seconds of exercise and remains for the next 60-80 seconds. Edward et al (8) suggests that an enhanced venous return to the central circulation, via the action of the active muscles, could account for the more rapid increase in oxygen consumption.

1.2.3 Blood, pH, pO2, and pCO2

In general, blood plasma carbon dioxide may be expected to be lower than normal in pregnant women during moderate exercise, since hyperventilation is already evident during rest. However, the blood plasma carbon dioxide is unchanged, even though the blood pH is decreased during short-term cycle exercise at 80W (24). The response during a more intense exercise effort in humans is not known. It may be that the elevated blood pH, lower plasma carbon dioxide or unchanged or elevated blood plasma oxygen found in late pregnant ewes during treadmill exercise, could also occur in mammals (27).

1.2.4 Endocrine systems

The endocrine systems undergo profound changes in pregnancy (22,24,28). There is a moderate and progressive increase in Adrenocorticotropic hormone (ACTH) secretion during pregnancy (22). It is followed by a rise in both total and free plasma cortisol concentrations. Plasma growth hormone levels are low, and its secretion in response to stimuli, such as arginine or hypoglycemia, is blunted. Thyroid-stimulating hormone (TSH) secretion may be reduced during the first trimester of pregnancy, and thereafter secretion does not differ from that in healthy non-pregnant women. Nonetheless thyroid function is normal during pregnancy, probably due to the presence of human chorionic thyrotropin (24). The concentrations of total plasma thyroxin and triiodothyronine increase during pregnancy. However, there is a related increase in the principle binding protein, thyroxin-binding globulin, in plasma. Therefore, the levels of free thyroxin and triiodothyronine remain essentially normal during pregnancy. Resting circulating catecholamine concentrations in humans also remain normal. Plasma insulin and glucagon levels increase during pregnancy. However, on a molar basis, the insulin level increases more than the glucagon level; therefore, the molar insulin: glucagon ratio increases during pregnancy (24). Normally, this should result in a more dominant insulin influence in the body. However, in reality this does not happen and there is actually insulin resistance during pregnancy (28). During pregnancy the placenta plays an important role as a multifunctional endocrine gland. One hormone secreted is human placental lactogen. This hormone antagonizes the peripheral action of insulin and has a lipolytic effect in adipose tissue (29). These data suggest that the endocrine response to exercise may differ during pregnancy from that found in non-pregnant subjects.

1.2.5 Metabolism

Resting oxygen consumption of the mother increases in a somewhat biphasic manner, to approximately 15-29% above normal, during pregnancy. The initial increase is primarily due to increased cardiac and renal energy costs; these remain essentially constant throughout pregnancy. The major increase in resting oxygen consumption, which occurs during the second half of pregnancy, is due to the rapidly growing fetus, the enlarging placenta, and the uterus (24). However, in situations of marginal nourishment there is some evidence that mothers adjust their metabolism thereby sparing nutrients for the development of the fetus (23). Additionally, when there is chronic undernutrition, the limits of adaptation might be exceeded leading to fetal growth retardation.

Fat accumulation in the mother is one of the most obvious metabolic adaptations during pregnancy. On average, approximately 3.5kg of fat accumulates, primarily during the first half of pregnancy. The circulating free fatty acid concentration increases in the third trimester of pregnancy to nearly 2-4 times normal (500-1250μM). Similarly plasma triglyceride concentration increases during pregnancy, and near term it is approximately three times the normal value. Plasma ketone levels are also markedly increased in late pregnancy (24). During a glucose tolerance test, the peak concentrations of glucose and insulin in the plasma become progressively higher throughout the duration of pregnancy. It has been estimated that during late pregnancy the sensitivity to insulin is reduced by as much as 80% (28).

1.3 Effect of exercise during pregnancy on the mother and the fetus

Exercise in the normal adult is also associated with an increase in cardiac output, metabolic rate, body temperature, substrate mobilization and utilization and biomechanical stress. However, in contrast to pregnancy it redistributes the blood flow away from the splanchnic organs to the muscles and skin. The vascular tone increases, blood pressure rises, and the circulating volume falls by approximately 20%. The blood levels of catecholamines and glucagon increases as a result of exercise whereas insulin release and that of other tropic hormones is suppressed. The hepatic clearance rate also decreases due to a decrease in blood flow through the celiac axis (22,23).

The mother and fetus could be at an increased risk when the combined physiological consequences of exercise and pregnancy are considered. The relevant literature in this regard is presented below.

1.3.1 Fetal Risks

In response to exercise, potential risks to the fetus include hypoxemia, harmful heart rate changes, hyperthermia and problems associated with high altitude sports and underwater sports.

1.3.1.1 Hypoxemia

The decrease in blood flow to the uterus due to exercise may cause an inadequate oxygen supply to the fetus (30,31). Exercise induced increase in maternal catecolamines and a decrease in cardiac output could lead to hypoxia as catecholamine levels have a vasoconstrictory effect on the uterine and umbilical blood flow (32). Eventually this could lead to fetal bradycardia (abnormal slowness of the heart) and fetal distress. Laboratory studies in sheep have demonstrated that a decrease in oxygen tension and an increase in carbon dioxide tension occur as a result (33). Evidently, decreased fetal oxygen uptake with or without fetal acidosis, fetal bradycardia or both does not occur until the reduction in uteroplacental flow exceeds 50% (27,34,35).

Animal studies have shown that maternal exercise in late pregnancy produces transient fetal hypoxemia (19,22). However, there is no evidence at delivery to suggest that regular sustained exercise in late pregnancy produce recurrent fetal hypoxemia in the human (19,21). Transient fetal bradycardia has been observed in untrained pregnant women performing short-term high intensity exercise in late pregnancy (36,37). On the other hand, in fit pregnant women regularly engaging in sustained aerobic exercise at intensities between 40-88% VO2 max, the fetal heart rate has been found to increase consistently during exercise (38). This implies that the fetal heart rate response could be an adaptation to a minor fall in placental oxygen occurring as a result of a small progressive decrease in placental perfusion. The liver readily synthesizes erythropoietin whenever there is an intermittent or long-term reduction in fetal oxygen delivery (39,40). Clapp et al investigated this response in a study on erythropoietin production in the amniotic fluid at the time of membrane rupture in exercising women, as it is a biological marker of tissue oxygen availability (20). They found that the rise in circulating erythropoietin occurring in regular, sustained, strenuous exercise throughout late pregnancy was not associated with elevated erythropoietin levels at labor and delivery in the human (20).

1.3.1.2 Fetal heart rate changes

Fetal heart rate changes are another measure of uteroplacental insufficiency. Fetal heart rate recordings are used as summary indicators of well-being during and after exercise. In the third trimester of pregnancy, it is approximately 120-160 beats per minute, with an average of 140 beats per minute (24).

Depending on the extent of circulatory changes various fetal heart rate responses can be expected after exercise in pregnancy. Acceleration of fetal heart rate with fetal movement i.e. a reactive non stress test has been used to evaluate the antepartum fetal well being of the fetus with potent uteroplacental insufficiency (34). A reactive pattern required the presence of two accelerations of > 15 beats per minute and 15 seconds duration associated with fetal movement during a 20 minute period (32). Acceleration of fetal heart rate following maternal exercise could be related to factors such as fetal arousal, placental transfer of maternal catecholamines, an increase in maternal and fetal temperatures, or a reduction in uterine blood flow (41).

In response to exercise, studies have shown that the baseline fetal heart rate can initially decrease and then return to baseline levels before increasing (40). Several studies have found no change or an increase of not more than 30 beats per minute after exercise (32,38,40,42,45,).

A study by Hauth et al on women who jogged during pregnancy reported no fetal bradycardia (abnormal slowness of the heart) at anytime either before or after jogging (46). The fetal heart rate increased after jogging and the nonstress test was reactive on all testing occasions. However, the authors concluded that moderate maternal exercise does not result in acute fetal distress. Artal and colleagues investigated fetal heart rate patterns during strenuous exercise and reported fetal bradycardia in only three of the nineteen cases studied (36). Fetal bradycardia after exercise is of concern as it may reflect marked fetal hypoxia, fetal acidosis or severe hyperthermia (17,45). However, the bradycardia was of a transitory nature and appeared to be compensated by an increase in fetal heart rate after cessation of exercise. This could reflect a compensatory response in the fetus to overcome the brief periods of hypoxia.

Aerobic activity during pregnancy failed to produce cases of marked tachycardia or bradycardia either before or after exercise except in 10% of the cases (41). Tachycardia is rapid heartbeat and is a term usually applied to a pulse rate above 100 beats per minute. Moreover, aerobic activity during pregnancy did not interfere with normal fetal growth and development (41). No correlation was found between the individual fetal heart rate responses, gestational age, exercise intensity, and maternal circulating catecholamines in pregnant women involved in mild, moderate or strenuous exercise (32). Mild maternal exercise was not found to change the uteroplacental peripheral vascular bed resistance (47). Thus in healthy pregnant women, with no clinical complications in childbearing, fetal heart rate does not appear to be significantly affected in any predictable manner.

1.3.1.3 Hyperthermia

The increased heat production associated with exercise has detrimental effects on the fetus. Laboratory experiments in animals have shown that elevation of maternal temperature is associated with an increase in the risk of fetal malformations (48,49). The fetus is totally dependent on the mother for the dissipation of body heat. Under resting conditions the fetal temperature is about 0.5°C above that of the mother. Animal studies have shown that elevation of maternal temperature is associated with elevation of fetal temperature (50). The decline in temperature after exercise is more prolonged in the fetus than the mother, suggesting that heat exchange in the placenta is compromised during exercise. However, the increased heat production associated with endurance exercise and pregnancy brings about a variety of adaptive mechanisms to regulate body heat.

Exercise duration and intensity are important in determining the temperature increase. In a study by Clapp et al on women jogging prior to and during pregnancy, the exercise intensity and duration decreased in pregnancy (51). Likewise, the magnitude of the rise in rectal temperature also decreased. The authors suggest that this decrease in heat production could be due to the training effect and also heat acclimatization. Moreover, they speculate that the physiological changes associated with pregnancy increase the efficiency of heat dissipation due to increased blood volume and cutaneous circulation. Jones et al observed no change in the thermoregulatory response to sustained exercise during pregnancy (18). Another study by Clapp et al, reported a decrease in mean rectal temperatures by 0.3°C at 8 weeks and then a fall at a rate of 0.1°C per lunar month through the thirty-seventh week, which again suggests physiological adaptations to pregnancy (52).

1.3.1.4 Decreased barometric pressure

In activities like mountain sports performed at high altitudes hormonal and other factors intrinsic to pregnancy may be responsible for a two-fold increase in the maternal hypoxic ventilatory response. Maternal low exercise levels have not been found to be associated with significant fetal heart rate changes at altitudes 2500m or less. Moore et al found that pregnancy-induced hypertension was more frequent at an altitude of 3100m than at 1600m (53). They concluded that maternal hypoxia could play a role. High altitude living has been associated with fetal growth retardation. In addition, altitude induced hypoxia may aggravate maternal cardiac disease thereby compromising fetal well-being (54).

1.3.1.5 Increased Barometric pressure

Activities like scuba and snorkel diving performed at increased barometric pressures can result in mixing of the inhaled nitrogen in blood and other tissues (30). Thus accumulation of nitrogen in maternal tissue results. Accumulation in fetal tissue may occur as well. The fetus is at risk of malformation and gas embolism after decompression disease (54).

1.3.2 Maternal risks

The concerns regarding risks to the mothers exercising in pregnancy range from hypoglycemia during exercise sessions, chronic fatigue, the risk of injury, the effect that exercise could have on the heart rate of the mother, and the risk the increase in temperature could pose to the mother (22,23,55,56,57). Potential benefits for the mother are many and include increased fitness, reduced stress, prevention of excess weight gain, decreased risk of gestational diabetes, facilitation of labor, faster recovery from childbirth, and improved mood and body image (58,59).

1.3.2.1 Effect of injury

There is concern that certain physical activities involve chances of maternal trauma during pregnancy and are best avoided. During pregnancy, as a result of greater ligamentous laxity, heavier body weight, and change in the center of gravity, pregnant women are probably at increased risk of sprains, stress fractures, and falls (55,56). Direct trauma to the abdomen could result in maternal and fetal injury. The consequences will depend on the stage of pregnancy, the type and severity of the trauma and the extent of injury to the fetoplacental unit.

In a study of trauma cases, out of 84 women with abdominal trauma, after 25 weeks gestation 39% of the injuries were due to falls (56). Seventeen women from the 84 trauma cases i.e. about 20% had uterine contractions after the event. The authors suggest that a high number of falls in late pregnancy could probably be due to problems with balance because of a protruding abdomen. Trauma in late pregnancy can also cause abruptio placentae (premature separation of a normally situated placenta) and its incidence is estimated to be between 1 and 5 percent (57). This could be followed by fetal distress, fetal death, or long-term placental insufficiency. A review by Bell et al, reported that the risk of fetal injury is also high in late pregnancy due to a decrease in the amniotic fluid: fetal ratio (17).

Injury to the placenta can cause fetomaternal hemorrhage and the risk could be as high as 28%. Potential complications include Rhesus sensitization of the mother, fetal anemia, and in severe cases fetal death.

1.3.2.2 Effects of temperature

Heat production in pregnancy increases due to increased activity of maternal tissues and the fetoplacental unit. A rise in rectal temperature of up to 1.5 °C was found in late pregnant ewes after fairly intense treadmill exercise or prolonged walking to exhaustion (22). Exercise during pregnancy leads to even greater heat production due to the increased activity of the skeletal muscles. Dissipation of this excess heat poses a challenge to the maternal thermoregulatory processes especially when temperature regulation is complicated by environmental conditions (22,23).

1.3.2.3 Effect on heart rate

Studies on the effect of exercise on cardiac output have reported conflicting findings. Bader et al found cardiac output during exercise to be similar to a reference control response and to be stable throughout pregnancy (23). Knuttgen et al also found the cardiac output to be similar in pre and postpartum subjects (24). On the other hand Ueland et al found that the cardiac output to be higher during exercise compared to postpartum values (58). Moreover, the cardiac output was found to be elevated throughout pregnancy. The greater cardiac output was due to a greater stroke volume. The increase in cardiac output during exercise at 200 kpm.min^{-1} decreased gradually as pregnancy progressed, and near term the increase appeared less than that found postpartum. These gradual changes during pregnancy were due to changes in both heart rate and stroke volume. In a study by Guzman et al, the cardiac output was found to be higher throughout pregnancy than in the non-pregnant controls at all levels of cycle ergometry (26). This was due to heart rates and stroke volume in the pregnant subjects. It thus seems probable that exercise induced increase in cardiac output during pregnancy is essentially normal and adequate for the work demands.

1.4. Exercise with coexistent conditions unique to pregnancy

The potential risks and benefits of exercise during pregnancy with coexistent gestational diabetes and preeclampsia are reviewed below.

1.4.1 The effect of work in pregnancy on the risk of severe preeclampsia

Preeclampsia is a disease unique to pregnancy characterized by progressive hypertension, pathologic edema and proteinuria (61). It contributes substantially to maternal and fetal morbidity and mortality as it could lead to eclampsia, which is fatal (62). Eclampsia is defined as the onset of convulsions or coma during pregnancy or postpartum in a patient who has signs and symptoms of preeclampsia (63). Maternal deaths could occur due to intracerebral hemorrhage, pulmonary edema or renal hepatic or respiratory failure (63). Perinatal mortality and morbidity can occur; the main causes being preterm delivery, fetal growth retardation and abruptio-placentae (63).

The belief that preeclampsia is characterized by vasoconstriction has recently been challenged. In a study of nulliparous women with uncomplicated pregnancies, it was demonstrated that, preeclampsia is characterized by high cardiac output rather than vasoconstriction (61). Thus working conditions could play a role in the development of preeclampsia. Several studies have shown that the risk of preeclampsia is two times greater in women who worked during pregnancy as compared to those who were unemployed (63,65). In addition, moderate/high physical activity at work was associated with a 2-fold increase in the risk of severe preeclampsia compared to mild activity (63). Marcoux et al found that increased leisure time activity was associated with a reduction in the risk of preeclampsia probably because women spending longer hours at work have less time for leisure type activity (64). In another study conducted to identify the risk factors for severe preeclampsia in nulliparous and multiparous cases, it was found that severe obesity was a risk factor in all cases (66). Obese patients have an elevated baseline cardiac output, which increases even further secondary to pregnancy-associated physiological changes. Thus these patients cannot compensate further for the increase in cardiac output especially with increased physical activity. They may then develop hypertension while sustaining the increased blood flow leading to vascular lesions and the clinical picture of preeclampsia.

Thus the risk of preeclampsia is greater in obese subjects especially in those indulging in high amounts of physical activity during pregnancy (66).

1.4.2 Gestational Diabetes Mellitus

Gestational Diabetes Mellitus is a complication of pregnancy and occurs in 2-13% of all pregnant women (68). It is associated with increased risk for perinatal morbidity. Improved glucose control in pregnancy may minimize the risk of complications.

In a study, every one out of eight women with class A1 gestational diabetes delivered a large-for-gestational age infant attributable to glucose intolerance (69). Macrosomic infants born of mothers with gestational diabetes mellitus were found to have unique patterns of adiposity that are present at birth and persist at 1-year (70). Long-term studies of growth in infants of mothers with gestational diabetes have revealed increasing adiposity at ages 5-9 years in both normosomic and macrosomic infants, suggesting that the more important risk factor with increasing age is maternal diabetes (71,72). In a study of pregnancy outcome in insulin dependent diabetic mothers, 5.5% of the infants born had congenital malformations ranging from, congenital heart defects, to skeletal malformations and malformations of the visceral organs (73). Intensive treatment begun on another group of diabetic women before conception in the same study, revealed a significant reduction in malformations to 0.8%, indicating the importance of good metabolic control of diabetes in pregnant women (73).

It is well established that gestational diabetes mellitus is a disease of glucose clearance and is characterized by high glucose levels even in the presence of high insulin levels (74). Its treatment aims at maintenance of euglycemia i.e. a normal level of glucose in the blood. Diet therapy is traditionally used as a method of treatment. If this fails, insulin is used. Ideally, treatment should aim at methods that overcome insulin resistance. Increased insulin receptors have been found after exercise in patients with insulin-dependent diabetes mellitus. Cardiovascular conditioning exercise facilitates glucose utilization by increasing insulin binding to and affinity for its receptor (74). Jovanovic-Peterson et al studied the impact of a training program on glucose tolerance in gestational diabetes mellitus (75). Arm ergometer training was used and resulted in lower glycosylated hemoglobin, fasting and 1-hour plasma glucose concentrations, than diet alone. In another study on the efficacy of an exercise program in normalizing glucose tolerance in gestational diabetic patients requiring insulin it was found that 17 of the 21 patients completing the exercise program maintained normoglycemia without insulin therapy (76). Furthermore, in this entire study there was no occurrence of fetal late deceleration or bradycardia. A fetal late deceleration may be defined as a transient decrease in fetal heart rate occurring at or after the peak of a uterine contraction and resulting from fetal hypoxia. Bradycardia is slowness of the heartbeat as evidenced by slowing of the pulse rate to < 60 beats per minute. However, a partially home-based exercise program failed to reduce blood glucose levels, but did result in a modest increase in cardiorespiratory fitness (77).

Recently, a study was carried out to assess whether exercise results in a lower prevalence of gestational diabetes mellitus and to investigate whether there is an association between Body Mass Index, exercise, and the prevalence of gestational diabetes mellitus. The authors found no difference in the rates of gestational diabetes mellitus between women with a Body Mass Index of 30 or less, who exercised and those that didn't exercise during pregnancy (78). However, women with a Body Mass Index over 30 had lower rates of gestational diabetes mellitus if they exercised than those that didn't. In the Nurses' Health Study II, no association was found between the MET scores and subsequent gestational diabetes mellitus risk (79). Although the risk for gestational diabetes mellitus was found to be slightly lower with frequent participation in vigorous physical activity, the association was not significant enough in the cohort as a whole or among those women considered to be at high risk for gestational diabetes mellitus such as the obese women, or those with a family history of diabetes mellitus, or over 35 years of age. Despite studies showing the benefits of exercise in maintaining euglycemia, exercise as a form of therapy is not widely recommended in pregnancy because of the effect it may have on the uteroplacental and fetal circulation.

1.5. Occupational activity hazards and pregnancy outcome

More women who have been working before pregnancy continue their employment during gestation. More than half of all women now work (80). The increase in the number of women who work during pregnancy may be attributed to greater dependence on a second salary to support the family. Health care providers and working women are concerned whether work during pregnancy has any adverse pregnancy outcomes.

Women are now employed in the workforce in almost all areas of work. The impacts of occupational activity on pregnancy outcome are varied (36,47,81). Four physical stresses are associated with occupational activity, which include quiet standing, long hours of standing, protracted ambulation, and heavy lifting. It is believed that these stresses could cause intermittent but protracted reductions in uterine blood flow and increase intra-abdominal pressure (46). Premature rupture of the uteroplacental membrane could occur leading to a shortened duration of gestation. A short duration of gestation is associated with serious neonatal and infant morbidity (82).

In studies carried out to assess the impact of physical activity on the gestational age at delivery in women performing physical tasks in their job during pregnancy, it was found that the daily duration of tasks with a high physical workload was significantly correlated with a shorter gestational age at delivery (11,15). Prolonged standing and walking especially were found to increase the risk of preterm delivery in a prospective cohort of 8,711 women (83). A significant association was also found between standing and preterm birth, but not with low birth weight (84). With stand-up work activity right up to late gestation, not only was growth retardation in the infants observed, but also the frequency of large placental infarcts were found to increase (14).

The prematurity rate in a French study was found to be 8.3% in women involved in occupations requiring long hours of standing whereas in the other occupational categories, the rate was found to be 3.5%(85). The longer the standing hours the higher was the risk of premature births. A Montreal study on a large sample of about 22,761 pregnant women employed for more than 30hrs per week, revealed 7.4% of preterm births and 6.6% low birth weights (86). There was a large overlap i.e. 4.1% were both preterm and of low birth weight. Classified by occupation, the managerial sector had a low rate of preterm and low birth weight children. Those occupations involving a lot of standing such as the services sector had a slightly increased ratio of preterm births. Low birth weight was also found to be higher in occupations involving both standing and lifting (80). This was confirmed by another study, where intra uterine growth retardation (IUGR) was studied with the use of ultrasonography. Manual workers were found to be at a slightly higher risk for IUGR (14). Employment during pregnancy was found to be a risk factor for spontaneous as well as indicated preterm birth, in a study by Meis et al (87).

A prospective study of the effect of work-related physical exertion on the risk of spontaneous abortion found no association in 5,144 pregnant women (88). Physical exertion was measured as time spent working, standing and bending at work, hours between breaks, and hours spent doing housework or yardwork; shiftwork, number of times lifted heavy weight > 15 pounds at work or home; number of children under age 5 years cared for at home. Moreover, physical activity at home and work combined together was not related to increased risk either (88). A study of 5,552 pregnant women also revealed no evidence that work per se had any detrimental or beneficial effects on the risk of having a small for gestational age infant or preterm delivery (89). A study in Western Australia on energy expenditure and its effect on pregnancy outcome reported that women in the medium expenditure group delivered babies with higher birth weight and had fewer incidences of premature rupture of membranes as compared to women in the lower energy expenditure group who had increased risks of antepartum admission to the hospital. However, these results were not due to the physical activity levels as such but due to other confounding variables present (90).

1.6. Leisure time activity and pregnancy outcome

More and more pregnant women are continuing their leisure time activities during pregnancy. These include a wide range of sports such as swimming, diving, dancing, skiing etc. Many investigations have shown that women who participated in sports or physical fitness exercises during pregnancy had a significantly lower rate of preterm delivery as compared with those who were not active (91,92,93). Lack of leisure-physical activity during pregnancy was one of a number of factors contributing significantly to an increased risk for pre-term delivery (94,95,96).

Exercise in the water offers physiological advantages to the pregnant women (97). The hydrostatic force of water pushes extravascular fluid into the vascular spaces, producing an increase in central blood volume that may lead to increased uterine blood flow. This force is proportional to the depth of immersion. The increase in blood volume is proportional to the women's edema. A marked diuresis and natruresis accompanies the fluid shifts. The buoyancy of water supports the pregnant women. Water is thermoregulating. Studies of pregnant women exercising in the water have shown less fetal heart rate changes in the water than on land in response to exertion. Pregnant women's heart rates and blood pressures during water exercise are lower than on land exercise, reflecting the immersion-induced increase in circulating volume (97). However, pregnant females should refrain from diving, because the fetus is not protected from decompression problems and is at a risk of malformation and gas embolism (98).

Pregnant women exercising at high altitudes must do so with caution. In the first few days, exercise should be performed at lower altitude. The effects of exercise and altitude may be synergistic, and so an altitude of 2,500m (8,250 ft) should not be exceeded in the first 4 to 5 days of short-term exposure. Compounding risks, e.g., maternal smoking, anemia or fetal growth retardation must be carefully excluded (54).

1.7. Physical activity and the course of pregnancy, labor and delivery

Studies on the effect of exercise on pregnancy outcome present conflicting findings (99,100,101,102). Exercise during pregnancy poses potential hazards to the fetus as mentioned earlier in this review, such as early miscarriage, induction of premature labor, altered fetal development, shortened gestation, and reduced birthweight. Potential benefits include the possibility of fewer complications during labor and delivery when the mother is in good physical condition.

1.7.1 Length of labor

There is the general belief in the medical community that fitness for delivery is an asset to the mother. However, some obstetricians feel that intensive sport activities stiffen the pelvic floor and perineum, thereby making labor more difficult than for the normal population. In contrast, others consider that the strengthened abdominal muscles in the athletes are beneficial during the second stage of labor.

Research on the effects of exercise on length of labor has shown conflicting findings (103, 104,105, 106, 107, 108, 109). Erdelyli reported that 87.2% of 107 German female athletes delivered faster than the established average (103). Similarly, that group had fewer cesarean sections, fewer perineal tears, and shorter total duration of labor, with the third stage lasting only half as long as in non-athletes. Horns et al (104), have reported the findings of a study wherein the length of labor in 65 primiparae who did and did not attend exercise classes was studied. Women who participated in an exercise program had significantly shorter labors than those who did not. Kupla et al reported a shorter active labor phase in primigravidas who had participated in aerobic exercise during pregnancy (105). Clapp (106) found exercise throughout pregnancy to be associated with shorter active labor (223 vs. 302 minutes, $p<0.01$).

Pomerance et al, found a negative correlation between exercise and the combined length of first and second stages of labor in primiparae (107). No significant difference was found in length of labor of primiparae who did and did not exercise. Physically fit multiparae, however, were found to have shorter labors than multiparae who did not exercise. Hall et al, found no significant difference in mean length of labor in either primigravidae or multigravidae who had exercised during pregnancy (108). A retrospective study by Kardel et al, performed a detailed documentation of the physical activity of 42 women before conception, during pregnancy and delivery on the onset of labor (109). They found that the gender of the child affected the onset and duration of labor. A later onset of labor was found in the medium intensity activity group than in the high intensity activity group but only for mothers giving birth to girls, and a tendency for shorter duration of labor for both genders in the medium intensity group compared with the high intensity group. However, to objectively summarize the current research regarding the effect of exercise on the length of labor, a meta-analysis by Lokey et al, has reported that women who exercised during pregnancy did not differ form sedentary women in the length of labor (110).

1.7.2 Apgar Score

Wong and McKenzie found that newborns of primigravidae who engaged in regular exercise during pregnancy had higher 1-minute Apgar scores (111). No differences were found in the 5-minute Apgar scores. Additionally newborns of women who exercised at a high level had slightly higher Apgar scores than newborns of mothers in the control, low exercise level, and medium exercise level groups. Hall et al (108) reported that newborns of mothers who exercised at a high level had slightly higher 1-minute Apgar scores than newborns of mothers in the control, low exercise level, and medium exercise level groups. The mean 5-minute Apgar scores for newborns of mothers in the high exercise level group were slightly higher than those for newborns of mothers in the control and medium exercise level groups.

A review by Wallace and Engstrom on the effects of aerobic exercise on the pregnant woman, her fetus and pregnancy outcome, concluded that moderate exercise is safe for pregnant women who have no medical or obstetric complications (112). A recent study by Zeanah et al reported that women who exercised in excess of the American College of Gynecologists guidelines did not experience adverse affects from the activity (113). A meta-analytic review of research by Lokey et al (110), on the effects of exercise on pregnancy outcomes, found no significant difference in active and sedentary women for maternal weight gain, neonatal birth weight, length of gestation, length of labor, or Apgar scores. Still other reviews on the effects of exercise on pregnancy outcomes found no difference in the Apgar scores between newborns of women who exercised during pregnancy and newborns of sedentary women. A recent study found no significant difference in the Apgar scores between active and sedentary groups for caesarean delivered newborns or between the 1-minute Apgar scores for vaginally delivered newborns (104).

1.7.3 Birth intervention

Neonatal outcome varies greatly because of several possible influences including genetics, socioeconomic differences, maternal physical and health characteristics before and during pregnancy, nutrition, exposure to drugs and toxic agents, stress, obstetric care and exercise (22). Mostly cross-sectional studies have reported the long-term effect of physical activity on pregnancy outcome (103,105,107,114). These studies have been mainly on athletes and controls. Also some recent studies have been retrospective (93,108,116,117), there are others which are prospective (118,119,120,121).

Most studies suggest a normal or improved parturition and neonatal outcome for women who exercise during pregnancy. Compared to untrained women it has been shown that athletes and more fit women tend to have shorter labors (107,111), lower rates of complications during pregnancy and similar childbearing capabilities (103,122). Other prospective studies suggest no difference in pregnancy outcome in women exercising during pregnancy compared to those who did not. A few studies suggest that exercise during pregnancy may be related to the type of delivery, but the direction of this relationship is not clear. Hall and Kaufman (108), found an inverse relationship between the amount of exercise during pregnancy and the proportion of caesarean deliveries, ranging from 6.75% in the high exercise group to 28.1% in the sedentary group ($p < 0.01$). This study is in agreement with the findings in a study of Hungarian athletes (123), in whom a low frequency of C-sections and forcep deliveries was found, but is in contrast with another study of runners, which reported greater likelihood of C-sections with greater exercise (183). Caesarean deliveries occur due to several reasons. These include fetal indications as well as maternal indications (82). Fetal indications include fetal distress, prematurity, fetal growth restriction, malpresentation, alloimmunization, fetal malformations, and multiple gestation. Maternal indications include preeclampsia, diabetes, invasive cervical cancer, dystocia (abnormal labor or childbirth due to some condition inherent in the mother), and previous caesarean. Maternal obesity and increased pregnancy weight gain have also been found to be associated with increased mean birth weight and caesarean rates (82).

1.7.4 Length of gestation

Gestational age is the most important factor that determines perinatal morbidity. Mixed results have been obtained from studies on exercise, birth weight and gestational age. No difference in birth weight or gestational age has been found in some studies. In a study by Clapp and Dickensen, continued, sustained endurance exercise during pregnancy significantly reduced gestational length (119). Another well-controlled trial by Clapp et al (124), found that women who continued to exercise during pregnancy at least 3 times a week for at least 30 minutes at an intensity greater than 50% of age-predicted maximum heart rate had shorter gestation, a higher incidence of small-for-gestational age babies and less gestational weight gain. These associations between exercise and shortened gestation have not been confirmed by other studies (108,125). A meta-analysis by Lokey et al (110), of 18 observational and interventional studies found no difference in the gestational age of infants born to exercising and non-exercising women.

1.7.5. Physical activity and birth weight

Birth weight is the single most important predictor of infant survival, since both neonatal and postneonatal mortality increase exponentially with decreasing birth weight (126). Apart from gestational age, birth weight is also known to be positively, influenced by maternal characteristics such as height, weight, age, and parity. Smoking, hypertension, lower social class and physical activity, influence birth weight negatively (127,128).

Starting a program of regular cycle ergometry, swimming, stretching, or multimodality exercise in the second trimester of pregnancy has been associated with either no change or a small increase in birth weight

(124,125,129). Several retrospective and epidemiological studies have also reported similar findings when regular walking and running is continued throughout pregnancy (38,130). However, when exercise volume is prospectively monitored, birth weight is significantly reduced in infants of women maintaining regular, vigorous, and sustained exercise throughout pregnancy and is increased in those who stop in late pregnancy (124). Moreover, it has been observed that in those who continue, the reduction in birth weight is directly related to the overall level in late pregnancy and is primarily due to a decrease in fat mass (about 220 gm). The remainder (about 100gm) is explained by the 5-day difference in gestational age at delivery (124). Head and axial growth has been found to be unchanged. An increase in low-birth-weight infants has been observed in women who work in adverse conditions or in jobs with known hazardous exposures. Thus it seems that the relationship between exercise during pregnancy and birth weight may be U-shaped. Clapp et al speculate that at low levels of physical activity, the effects on maternal blood volume, insulin sensitivity, placental growth, and rest-activity cycles may actually improve fetal substrate availability and growth (38). At higher levels of performance the effects are balanced, whereas at very high levels the adaptive mechanisms may not entirely compensate and caloric storage as fat is reduced.

1.7.6 Cord entanglement and clinical evidence of fetal distress

There are no reports of an increase in fetal cord entanglement, meconium staining, fetal heart rate abnormalities during labor, low Apgar scores, or neonatal complications in exercising women. In one study the incidence of these findings was found to be significantly decreased or similar to a closely matched population (124). Likewise, erythropoietin levels were not found to be elevated in newborns of exercising mothers (131). Moreover, in fit women, fetal heart rate responses to sustained exercise were not found to suggest fetal hypoxia (130). However, 10% to 20% of fetuses of healthy, relatively unfit women have been found to experience transient decreases in heart rate during and immediately after both moderate- intensity, sustained cycle ergometry and rapidly progressive submaximal cycle ergometry, suggesting that exercise in this population may significantly reduce uterine blood flow and fetal oxygen tension (132).

1.8. A review of methods used for assessing physical activity

Methods for assessing physical activity include, direct and indirect calorimetry, doubly labeled water technique, questionnaires, heart rate monitoring and accelerometry or pedometry (133,134,135,136). The advantages and disadvantages of the different methods of data collection are discussed in the following paragraphs.

Energy expenditure in humans is typically measured by either direct or indirect calorimetry (133). Direct calorimetry involves measurement of heat production directly. This approach is technically demanding, especially in human studies, and is therefore infrequently used, especially in population studies (133). Indirect calorimetry measures energy production by respiratory gas analysis (133). This method is based on measurement of oxygen consumption and carbon dioxide production that occurs during the combustion (or oxidation) of protein, carbohydrate, fat and alcohol. One of the limitations of using indirect calorimetry to measure resting metabolic rate is that measurements can be performed over only a very short time (usually 30 minutes). Measurements over 24 hours can be achieved by having subjects live in a metabolic chamber. Thus the disadvantage in using this technique for the present study is that free-living expenditure cannot be measured other than by confining the subject in a metabolic chamber for the entire activity period. Moreover, even for short measurement periods, the subject has to wear a facemask or a mouthpiece, or canopy system for gas collection (133). This method is therefore unsuitable for such large-scale studies. Thus although direct and indirect accurately measure energy expenditure, they are so intrusive that they alter activity patterns (134).

Free-living energy expenditure can be accurately measured by using the doubly labeled water technique (135). It is a noninvasive technique, which can be used to estimate energy expenditure from activity when combined with measurement of resting metabolic rate. However, it is an expensive technique requiring an isotope ratio mass spectrometer for sample analysis. It is thus unsuitable for large-scale epidemiological studies. This method provides a direct measure of carbon dioxide production but not of energy expenditure, as the food quotient of the diet is required for generating estimates of energy expenditure.

Heart-rate monitoring is an alternative method, which has been found to provide close estimation of total energy expenditure of population groups in validation against whole body calorimetry and the doubly labeled water method (135,136). However, the appropriate use of this technique requires a proper and undisturbed minute-by-minute heart rate recording during a period of at least three days. It also requires a calibration procedure in each subject in order to determine the individual relationship between oxygen uptake and heart rate exceeding a predetermined heart rate level at light, moderate and heavy work loads. Requirement of the resting heart rate and basal metabolic rate for each individual restricts the use of this method.

Questionnaires may be useful for large-scale epidemiological studies (137). They are more practical to use in a population setting, as they are an inexpensive method. However, the major difficulty with the questionnaire approach is that it relies on the ability of the subject to recall behavioral information accurately. Another difficulty with these questionnaires is translation of qualitative information on physical activity to quantitative data (138). It is also difficult to establish the validity of questionnaires used. There is a lack of standards against which the physical activity recall and other physical activity assessment techniques can be judged. Use of an activity diary to record daily activity from time to time helps to reduce the subjective error (135).

Activity diaries have been used for several decades in the assessment of physical activity (135,138). These methods do not rely on complicated methodology, are inexpensive and therefore suitable for population studies.

Data from the physical activity diaries is classified using different classification systems. The Compendium of Physical Activity used in this study (138), is an internationally used system of classification, which provides a comprehensive system for coding physical data on physical activity by purpose and energy cost. The energy cost of specific activities listed in this Compendium were obtained primarily from the previously published physical activity energy expenditure lists: Tecumseh Occupational Questionnaire, Minnesota Leisure Time Physical Activity, McArdle, Katch, and Katch's physical activity list, the 7-day Recall Physical Activity Questionnaire, and the American Health Foundation's physical activity list.

In this compendium all activities are assigned an intensity unit based on their rate of energy expenditure expressed as METS. The intensity of activities in the Compendium is classified as multiples of one met or the ratio of the associated metabolic rate for the specific activity divided by the resting metabolic rate. One MET is defined, as the energy expenditure for sitting quietly.

Thus,

$$1MET = 3.5ml\ O_2 / kg\ body\ weight / min$$

or

$$1\ MET = 1\ kcal / kg\ body\ weight / hour.$$

Moreover, this Compendium is organized by activity types or purpose and includes activities of daily living or self-care, leisure and recreation, occupation, and rest. The major headings in the Compendium explain the reason a person is engaging in a specific activity and is useful in categorizing activity types.

1.9. Study Objective

The objectives of this study were:

- To provide baseline data on activity levels during pregnancy in a sample of New Zealand European, Maori and Pacific women.
- To examine the association between activity levels during pregnancy on maternal medical issues during pregnancy and birth e.g. use of birth interventions, length of labor.
- To examine the association between activity levels during pregnancy on the gestational age, health and birth weight of the baby.
- To examine the effect of physical activity on weight gain during pregnancy and weight retention post partum.

Chapter two: Methodology

Introduction

This study was part of a larger New Zealand Ministry of Health funded study by Watson and Mac Donald on nutritional status during pregnancy (120). The methodology used in this study is based on that used in the Manawatu study by Watson (121).

2.1Pilot Studies

Two pilot studies were carried out by Watson in the Manawatu Survey (121). The first was to determine the sample size and number of measurement days required to accurately assess mean group energy and nutrient intake and mean group energy expenditure. In this study, 21 women in the 18-35 year old age group kept weighed diet records and 24 hour, minute by minute, activity diaries for 14 days. Resting metabolic rate and energy expended during all usual activities was measured using standard procedures. Anthropometric measurements were recorded at the beginning and end of the experimental period. The second pilot was carried out on 12 subjects to test and retest the questionnaires used.

2.2 Ethical Issues

Approval from the Ethics Committee of Massey University and Auckland Healthcare was obtained by Watson. All subject information was kept confidential and located in a locked office. The same data collector visited each subject. No names appeared on any forms, and a coding system was used to identify the subjects. Only the staff working on the study were given access to the data gathered for the study (120).

2.3. Techniques of Data Collection

2.3.1 Anthropometric Measurements

Measurements were made according to the procedures set out in 'Principles of Nutritional Assessment' (139). Maternal weight (without shoes and in minimal clothing) was measured on Tanita 1609 digital scales calibrated regularly against a Souter platform scale accurate to 200kg ± 0.02kg. Height was measured using a portable stadiometer. Triceps, biceps and costal skin folds were measured using Harpenden-Holtain calipers (120). Results of the Manawatu Survey showed that the biceps to costal skin fold ratio, followed by the triceps skin fold were the maternal skin folds most significantly related to birth weight, weight at one year, and post-pregnancy weight change (121).

2.3.2 Assessment of Physical Activity

Data were collected on one page, 24-hour activity record sheets with each hour being broken up into six, 10-minute slots. The principal activity in each 10 minutes was recorded. This was a simplified version of the activity diary used in the Manawatu survey (121) and designed by Watson to reduce respondent burden. Two 24-hour activity records were kept in month four and two were kept in month seven. At least one weekend day was included in this period (120).

The Manawatu Study (121) showed there were no significant differences in the time spent on the different activities in each energy expenditure groupings i.e. sleep, sedentary, moderate low, moderate high and high levels in month four and month seven of pregnancy. Analysis of variance in energy expenditure in the pilot study showed that three days of measurement were necessary to characterize individual energy expenditure to within ±10 percent of the true mean with 95% confidence. The four measurement days thus provide an accurate picture of the time spent by each individual on the activities within each energy expenditure grouping.

2.3.3 Questionnaires to Determine Cultural, Social, Birth details and Pregnancy outcome

Revised versions of the Manawatu Study (121) questionnaires were used. During development for the Manawatu Study these questionnaires were subject to extensive peer review. However, all of these reviewers were European. The data collection sheets, questionnaires and survey information sheets were reviewed by health workers and interested groups in the Maori and Pacific communities. Their corrections and suggested additional questions were incorporated by Watson (120), and the questionnaires retested on a sample of 12 Maori and Pacific women.

2.4. Subjects

2.4.1 Sample size

The analysis of variance in energy expenditure in the pilot study showed that 500 subjects measured for three days was necessary to characterize individual energy expenditure to within ±10 percent of the true mean with 95 percent confidence (120).

2.4.2 Sample Selection

Pregnancy is a non-random event hence it would be very difficult and expensive to obtain a random sample of pregnant women. Instead volunteers were sought from targeted clinics and geographical areas. Urban and rural Maori midwifery clinics and Pacific urban midwifery clinics were selected for distribution of volunteer information as a study objective was to over sample urban and rural Maori and urban Pacific women. In addition the publicity measures detailed in Section 5, were concentrated in selected lower socio-economic areas of Auckland, and rural New Zealand to bias the sample in this direction (120).

2.4.3 Sample Description

Volunteers around 14 weeks pregnant were sought. The study was open to all healthy women regardless of parity. A total of 505 urban and rural women living between Taupo and Welsford volunteered for the study and 504 took part. The sample contains 102 Maori and 48 Pacific women and hence compared with national census data these ethnic groups are over represented. By the second visit at seven months 29 subjects had withdrawn. Of these 15 had withdrawn because of the respondent burden or other non-specified reasons, four subjects were too ill to continue, four subjects were hospitalized for the third trimester, three subjects went overseas, two subjects moved out of the study area, and one subject had a miscarriage and left the study (120).

For the follow-up birth details questionnaire after pregnancy, only 228 women were interviewed as within the time frame of the research for this thesis, only these women had delivered and could be followed up. The time of administration of this questionnaire ranged from 0 to 15 months as some women who had enrolled earlier on in the study had already delivered. There were other women who had enrolled later and thus due to the delay in enrollments, this study was delayed and therefore the wide range in the time of administration.

2.5. Publicity and Recruitment

Widespread publicity in marae, community centers, medical centers, clinics, Plunket rooms, churches, libraries, Kohanga Reo, kindergartens, playcentres, parents centers, gyms and sports clubs, shopping centers, General Practitioners' and midwives waiting rooms was arranged by the project manager or data collectors in the communities from which volunteers were sought. Articles in local free newspapers and comment in local radio community notice board was also used to make the study known. A TV appearance on the '5.30 With Jude' programme, along with a 0800 free phone number for potential subjects to ring also provided publicity. Radio 531PI ran a series of paid advertisements for two weeks and free advertising for a further two weeks (120).

General publicity material displayed contact phone numbers and addresses. Specific handouts were also available to medical centers, G.P.'s and midwives' clinics for distribution to their pregnant patients.

Volunteers either telephoned the study organizers, sent in the tear off sheets provided around the community or were contacted by data collectors of their own ethnicity. Because of the widespread publicity the proportion of eligible pregnant women that knew about the study but chose not to volunteer, was not known.

Specific arrangements were as follows. Midwives working in the birth units, clinics and small maternity units in the North Auckland area assisted with recruiting volunteers. National Women's Hospital Central Clinic's manager and team managers also assisted with recruiting volunteers and allowed interviews to be conducted at clinics if necessary. Volunteers were also recruited through community advertising in free local newspapers etc. The Waipereira Trust health workers/midwives and Maori Community health workers assisted in recruiting Maori volunteers. The Whare Raupora at Glen Innes was the main contact point. Te Hotu Manawa Maori trainee health workers helped with recruiting volunteers in the Waikato. The Pacific Liaison nurse at National Women's Hospital helped with recruiting data collectors. The Oasis Resources AnteNatal Project nurse and midwives assisted with recruiting Pacific women volunteers (120).

2.6. Data Collection, Classification and Analysis Program

The data collection area was broken down into smaller geographic units and data collectors were assigned to each geographic unit. Fifteen data collectors were employed in all; 4 European, 7 Maori and 4 Pacific. The ethnicity of the data collector was matched to the volunteer. e.g. Maori interviewers to Maori subjects.

The data collection programme was as follows:

Month Four Pregnancy Visit	Two-day physical activity diary One, 24-hour recall diet Three- day food record Height, weight, skin folds Biochemical measures Questionnaire
Month Seven Pregnancy Visit	Two-day physical activity diary One, 24-hour recall diet Three- day food record Height, weight, skin folds Biochemical measures Questionnaire
Post Pregnancy Telephonic Follow-up	Questionnaire

Data entry, data checking, programming and statistical tasks were divided up among a team of nine data analysts, overseen by the biostatistician (Mac Donald) and project leader (Watson) (120).

2.7 Subject Feedback

When data collection was complete each subject was sent an analysis of her physical activity and body composition changes as well as an outline of major study findings. In addition, the Maori and Pacific communities received a detailed analysis of the findings for their group alone, to use as they saw fit (120).

2.8. Contribution of the thesis writer to the study

2.8.1 Questionnaire design

The after birth activity questionnaire collected information on the birth process, birth details, pregnancy complications and paid work status, before, during and after pregnancy. Most questions were adapted from those used in the Manawatu study (121). However, questions 7 to 12 were specifically designed by the thesis writer (See Appendix pp 154-158).

2.8.2 Data collection

The after birth activity questionnaire was administered via telephone by the thesis writer, and not the original data collectors assigned to that subject. Not all subjects could be contacted by phone and the thesis writer posted the questionnaire to these people with instructions on how to fill it out. Within the time-frame for the thesis research only 228 women had given birth and could be interviewed or contacted by post to provide after birth details.

2.8.3 Data entry and analysis

The thesis writer analysed the two month 4, and two month 7 activity diaries for all subjects, and checked and entered the data into the computer. She also coded, entered and analysed the data from the after birth activity questionnaire.

2.8.4 Analysis details

Details of the analysis carried out by the thesis writer are described below:

2.8.4.1 Activity data classification and analysis

2.8.4.1.1 Minutes spent on each activity

Data from the activity diaries (See Appendix pp 147-150) was classified as number of minutes spent in sleeping, daily physical activity, occupational physical activity and leisure time physical activity. This classification was done using the Compendium of Physical Activities (138). The data classification sheets consisted of 1 cm square boxes in which the time spent in minutes on each activity during each hour of the day was noted. (See Appendix pp 150.) The total number of minutes spent on each activity was then calculated for both two-day records. The average of these values was then calculated for both month 4 and month 7 and entered in Minitab worksheets for analyses.

One MET is defined, as the energy expenditure for sitting quietly, which for the average adult is approximately 3.5ml of oxygen. kg body weight $^{-1}$.min^{-1} or 1 kcal. kg^{-1} body weight. h^{-1}. Activities were grouped into different groups such as sleeping, stationary, moderate low activity group, moderate-moderate activity group and high activity group. The number of minutes spent in sleeping was put into the sleeping group. The stationary activity group included activities such as sitting, standing, standing and walking very little as in folding, making a bed, laundry, bathing (1.0-2.0 METS). Activities of moderate low intensity such as shopping, cleaning, vacuuming, dressing, feeding animals, pushing a stroller with a child in it, fast walking were included in the activity range of 2.5 to 3.0 METS. Farm activities such as milking the cows, gathering wood, moving stock, putting up the fence were grouped in the moderate-moderate intensity activity group ranging from 3.5 to 5.0 METS. Other activities such as working as a masseur, lawn mowing, gardening, dancing, playing games such as miniball, swimming, biking, and exercises such as stretching, weight training, brisk walking were also included in this category. The high activity group included activities of intensities ranging from 6 to 10 METS, and included activities such as stepping exercises, treadmill walking, power riding, playing tennis, netball, running, wood chopping, horse grooming etc. For purposes of analysis, the cumulative activity groups were calculated i.e., sleeping, sedentary (sleeping + stationary), moderate-low (sleeping + stationary + moderate low), moderate-moderate (sleeping + stationary + moderate-low + moderate-moderate).

2.8.4.1.2. Intensity of physical activity and energy expenditure

The time spent in physical activity was multiplied by the MET value of different activities as given in the compendium, to obtain a quantitative measure of exercise performance. These intensity values were grouped in the same activity groups such as sleeping, stationary, moderate-low, moderate-moderate and high. Analysis was done using this product in order to see if there was any difference in activity intensity by occupational status, ethnicity, location, income and educational status.

Energy expenditure was calculated by multiplying the body weight in kilograms by the MET value and duration of physical activity. These energy expenditure values were grouped similarly to the activity groups for time, such as sleeping, stationary, moderate-low, moderate-moderate and high. For purposes of analysis, the cumulative activity groups were calculated i.e., sleeping, sedentary (sleeping + stationary), moderate-low (sleeping + stationary + moderate low), moderate-moderate (sleeping + stationary + moderate-low + moderate-moderate).

2.8.4.2 Analytical Methods

Data analysis was performed by computer using Minitab, version 12.1. The ethnicity, educational background, occupational status and income levels were described using descriptive statistics. Cross tabulations of income with training, income with race, and training with occupational groups were done.

The means, standard errors of means, medians, upper and lower quartiles of all anthropometric measures of the mothers were calculated using descriptive statistics. Some anthropometric measures were also described by ethnicity and occupational status using descriptive statistics. The

Kruskal-Wallis test of significance was performed for non-normally distributed groups, and one-way analysis of variance for normally distributed groups to see if the differences between the groups were significant ($p<0.05$).

The descriptive statistics for time spent in minutes by ethnicity, educational status, occupational status and income levels were calculated. Descriptive statistics using the activity intensity and energy expenditure was also performed by ethnicity, occupational status, income level, location and educational status. To test the significance of the results, the Kruskal-Wallis test for non-normally distributed groups, and the one-way ANOVA for normally distributed groups was used. These tests determined the significance at 95% confidence interval ($p<0.05$).

Descriptive statistics was also used to calculate the time spent in physical activity in relation to the socio-cultural background of subjects. The significance of the differences in the parameters was tested using the Kruskal-Wallis test of significance for non-normally distributed groups, and the one-way ANOVA for normally distributed groups.

The means of the activity intensity in METS and the socio-cultural background of subjects were calculated using descriptive statistics and their level of significance were tested using the Kruskal-Wallis test of significance for non-normally distributed groups and one-way ANOVA for normally distributed groups.

The percentage of women hospitalized during pregnancy for various reasons was calculated using the tally function in Minitab. The percentage of women with spontaneous and induced labor, and elective Caesarean section were also calculated using the tally function in Minitab. Chi-square analysis was performed for determining the percentage of women using birth intervention and pain relief. The p-value was $p< 2.61$.

The need for birth intervention was tested by location and ethnicity, using the one-way ANOVA for normally distributed groups and the Kruskal-Wallis for non-normally distributed groups. Since the numbers in the Maori and Pacific pregnant mothers were too small to carry out analysis effectively, these two groups were combined and a chi-square analysis was done if there was any difference in the need for birth interventions. A two-sample test was also done, to see if any real difference existed between the ethnic groups.

The percentage of women needing pain relief and the different types of pain relief was calculated using the tally function in Minitab. The need for pain relief was tested by location using one-way ANOVA for normally distributed groups and the Kruskal-Walllis test for non-normally distributed groups.

The association between physical activity and the need for birth interventions was calculated using simple regression. Sedentary activity was then divided into tertiles and sorted in descending order. The percentage of women using birth intervention in relation to the tertiles of sedentary activity was then cross-tabulated and a chi-square analysis was done.

A regression analysis was done to see if there was any association between pain relief and physical activity was calculated. Since moderate high activity and pain relief showed a significant relationship, this activity category was again divided into tertiles and sorted. Cross tabulation was then done. A chi-square analysis was used to establish the significance of the differences.

The length of labor was described using descriptive statistics. The length of labor was also described by occupational status and ethnicity using descriptive statistics. The length of labor was regressed against physical activity to see if there was any relationship between the two. The results were presented using a graph. The length of labor and physical activity intensity were also regressed against each other.

The birth weights of the babies were also described by the sex of the babies using descriptive statistics. The percentage of infants needing special care after birth was calculated using the tally function in Minitab. The length of stay was also reported using descriptive statistics. A regression between length of stay and physical activity was done to see if there was any relationship. The percentage of infants needing hospitalization for various reasons was calculated with the tally function. Those needing special care after birth and the birth weight of the infants was regressed against each other.

A regression analysis was done to see if there was any relationship between infants needing special care after birth and physical activity. The anthropometric measures of the babies were also described by ethnicity and occupational status. The significance of the results was also tested using one-way ANOVA for normally distributed samples and Kruskal-Wallis test for non-normally distributed.

The impact of occupational status, ethnicity, income level and educational status on the birth weight of the baby was tested using regression. The birth weight of the baby was also regressed against the anthropometric measures of the mother such as weight before pregnancy, weight at fourth month of pregnancy, weight at seventh month of pregnancy, height of the mother, triceps and costal skin fold thicknesses at fourth month, biceps, triceps and costal skin fold thicknesses at seventh month of pregnancy, to see what factors affect the birth weight of the babies. A regression analysis was also done to see if physical activity (both time and intensity) affected the birth weight of the babies.

To determine the gestational age, first, the difference between the date of birth and the expected date of birth was calculated. The number of days early or overdue was then respectively subtracted or added to 280 days, which is the normal duration of a pregnancy. The gestational age was then described by the mean and the range values. Coding of the data on number of days premature, on time, or overdue was done to tally the percentage of pregnant women in each category. Gestational age was also described by ethnicity and location and their significance tested using one-way ANOVA for normally distributed samples and the Kruskal-Wallis test for skewed samples. Gestational age was regressed against physical activity to see if there was any relationship between the two. A two sample-test was done to see if the difference in the means of the upper and lower quartiles was significant. The results have been presented as a graph.

The percentage of infants born large-for-gestational age, and small-for-gestational age was then calculated using >4000g and < 2500g as cut-off points respectively. A cross tabulation of infants born large-for-gestational age with the number of days early, on time, or over the due date was done. Similarly, the number of small-for-gestational age infants, were cross tabulated with the number of days born early, on time, or over the due date to get the percentage in each category.

Weight gained in the fourth month of pregnancy was regressed against time spent in physical activity and also against the intensity of physical activity. Weight change between the fourth to seventh month of pregnancy was regressed against time spent in physical activity during the fourth month of pregnancy and seventh month of pregnancy separately. Weight change between the fourth to seventh month of pregnancy was then regressed against intensity of physical activity.

A regression analysis of time spent in physical activity and postpartum weight change was done to see if physical activity in the fourth and seventh month of pregnancy had any impact on the weight retained postpartum. Similar analysis was done using intensity of physical activity instead of time spent in physical activity. Weight retained postpartum by ethnicity, occupational status, educational status and income was tested using one-way ANOVA for normally distributed samples and Kruskal-Wallis test for skewed samples.

Chapter three: Results from the analysis of body composition changes and activity levels during pregnancy

3.1 Cultural and occupational background of subjects

Results

In this study, five hundred and four pregnant women were studied. Twenty-six percent of the population studied was rural and 74% was urban. The study population comprised 71% percent European subjects, 20% Maori subjects and 9% Pacific people (See Table 1).

Subjects and their partners were divided into two occupational groups, based on the ISO 800 occupational classifications. In the few situations where the male partner was unemployed, but the female partner was in work, the occupational category of the female was used for classification purposes. The upper occupational group includes managers, professionals, technicians and associate professionals. The middle occupational group includes clerks, service people, farmers, trades people, machine operators, laborers and those in unspecified occupations. The third group includes unemployed men with unemployed partners, and also unemployed solo women on benefits.

The educational and occupational status of the subjects is shown in Tables 2 and 3 respectively. The majority (45.2%) of the subjects had attended a technical institute. Almost half the subjects belonged to the middle occupational group.

Table 4 shows the income levels of the subjects. Almost 69% of the subjects earned more than NZ $35,000 per annum. The relationship of income to educational level and ethnic group is shown in Tables 5 and 6 respectively. The results show that 73% of those with a technical qualification, and 76% with a university qualification belonged to the highest income category in this study. Whereas 78% of Europeans were found to be earning more than NZ $35,000 per annum, only 49% of Maoris and 40% of Pacific people were earning more than this amount.

About 69.6% of women worked during pregnancy. Part-time work was done by 31.7% and 37.9% worked full-time. On an average, most pregnant women in this study sample worked for 20.2 hrs per week. Most women, (about 51.8%) stopped work during the third trimester, 6.2% during the second and 2.2% during the first trimester. However, 9.3% did not stop work during pregnancy and continued to work right up to birth.

Table 1: Ethnicity of subjects (n=503)

Subjects ethnicity n=503	**Percentage of subjects**
European	71
Maori	20
Pacific Islander	9

Table 2 : Educational background of subjects (n=502)

Type of Education (n=502)	Percentage of subjects
University	23
Polytechnic	45
Job training/ No training	32

Table 3: Socioeconomic background of the subjects (n=502)

Socio group (n=502)	Percentage of subjects
Higher	39
Middle	50
Lower	11

Table 4: Income levels of subjects (n=502)

Income levels ($) (n=502)	Percentage of subjects
< 15,000	7
16,000-25,000	9
26,000-35,000	14
>35,000	69

Table 5 : The income of the subjects classified by training (n=502)

Total income ($)	University (%)	Polytechnic (%)	Job training/No training (%)
< 15,000	6	4	10
16,000-25,000	5	8	11
26,000-35000	11	13	18
>35,000	76	73	60
Don't know	2	3	1

Table 6: The income levels of the subjects by race (n=502)

Race	< 15,000	16,000-25,000	26,000-35,000	> 35,000	Don't know
European (%)	3	6	11	78	2
Maori (%)	15	15	17	49	4
Pacific Islander (%)	13	14	31	40	2

3.2 Anthropometric measurements of the subjects

Results

The average age of the women in this study was 30.9 years. The ages of the subjects ranged from 28 years to 35 years. The average height of the women in this study was 167.0 cms and the standard deviation was 6.2 cms. The range was 145.3 to 185 cms.

The mean, standard deviation and measurement range for age, weight before pregnancy and month four and seven, height, body mass index and sum of the skinfolds at the measurement intervals throughout the study are shown in Table 7. Pre-pregnancy weight was self-reported. Body Mass Index (BMI) for European women was categorized into groups as follows: underweight, less than 19.9; normal weight 20-24.9; overweight, 25-30; and obese greater than 30.01. BMI for the Pacific women and the Maori women was categorized into groups as follows: underweight, less than 19.9; normal weight 20-25.9; overweight, 26-32; and obese greater than 32.01.

Using BMI cut-off points, 19.2% of the European women in this study were found to be underweight, 55.0% were found to have normal weight, 18.8% were found to be overweight and 7% were found to be obese.

Among the Maori and Pacific mothers, 10.8% were found to be underweight, 54.2% in the normal weight range, 22.5% were found to be overweight and 12.5% were found to be obese.

The average weight gain from zero to four months was 6.1 kg. The standard deviation was 4.7. The range was -14.1 to 26.0 kg. The average weight gain from zero to seven months was 11.2 kg. The standard deviation was 5.0 kg. The values ranged from -10.0 to 30.9 kg. The average weight gain between the fourth to the seventh month was 5.1 kg. The standard deviation was 3.0, and the range was -2.4 to 21.5 kg.

Maternal weight gain by ethnicity over the same period is given in Table 8. The Pacific people were found to be the heaviest between 0-7 months ($p<0.05$). The weight of the subjects before and during pregnancy according to occupational groups is given in Table 9. This shows that women in the middle occupational group were heavier than the other two groups before and during pregnancy ($p<0.05$). There was no significant difference in the postpartum weight retention, but the higher occupational group retained the most weight, whereas the lowest occupational group had no weight retention.

Table 7: Anthropometric measurements of the subjects (n=504)

	Mean	S.E. Mean	Median	Lower Quartile	Upper Quartile
Age (years)	30.9	0.2	31	28	35
Height (cm)	167.0	0.28	166.8	162.5	171
Weight before pregnancy (kg)	66.8	0.63	64.0	57.0	73.0
Weight mo 4 (kg)	73.6	0.63	71.2	64.3	79.7
Weight mo 7 (kg)	78.5	0.67	76.4	68.9	84.9
BMI pre-pregnancy (kg/m^2)	23.9	0.22	23.0	20.8	25.7
BMI at mo 4 (kg/m^2)	26.4	0.22	25.6	23.2	28.6
BMI at mo 7 (kg/m^2)	28.2	0.23	27.3	24.9	30.5
Triceps skinfold mo 4 (mm)	20.7	0.3	19.4	15.0	25.7
Triceps skinfold mo 7 (mm)	21.4	0.3	20.1	15.9	26.5
Biceps skinfold mo 4 (mm)	12.7	0.4	9.9	6.9	16.4
Biceps skinfold mo 7 (mm)	12.6	0.4	10.2	7.1	15.5
Costal skinfold mo 4 (mm)	21.2	0.3	20.5	26.3	16.1
Costal skinfold mo 7 (mm)	22.4	0.3	22.0	17.2	27.7
Triceps/Costal mo 4 (mm)	0.6	0.02	0.5	0.4	0.8

Table 8: Weight gain between the 0-4, 0-7 and 4-7months by ethnicity. (n= 504)

Weight Gain (months)		Mean kg	S.E. mean kg	Median kg	Upper quartile kg	Lower quartile kg
0 - 4	European	6.1	0.23	6.0	8.5	3.5
	Maori	6.0	0.68	5.5	9.2	2.1
	Pacific	6.4	1.24	6.5	11.4	2.6
0 - 7	European	11.0*	0.24	11.0	13.1	8.8
	Maori	11.2*	0.81	10.5	14.3	7.5
	Pacific	13.7*	1.53	14.2	18.7	8.5
4 - 7	European	5.0	0.16	4.6	6.6	3.1
	Maori	5.3	0.40	5.2	7.1	2.6
	Pacific	5.2	0.63	4.6	6.6	3.0

*$p<0.05$

Table 9: Difference in weight before, during and after pregnancy by occupational group (n=504)

	Group1 kg	Group2 kg	Group3 kg	P value
Pre pregnancy weight	63.0	65.0	62.0	0.052*
Weight at 4th month	71.8	75.4	72.2	0.021*
Weight at 7th month	75.5	77.5	72.2	0.004*
Postpartum weight	69.6	66.5	62.0	0.266

* $p < 0.05$

3.3 Physical activity during pregnancy

3.3.1 Time spent in minutes in different physical activity categories

Results

The physical activity of the study participants was categorized as leisure time, occupation related, exercise related, rural activity and general activity. Activities such as yatching, dancing, playing netball, fishing, horse grooming, gardening, weeding, planting, lawn moving, playing tennis, miniball and other sport were categorized as leisure-time activity. Occupational activities included activities which had to be performed as part of the occupation of the subject such as working as a masseuse, nursing, desk work, walking in the office, etc. Exercise related activity included activities which were especially mentioned as exercise, mostly with the duration and intensity specified such as aqua jogging, stretching, yoga, walking uphill, jogging running, power walking, working out on an exercise cycle or a power rider, or in a pump class etc. In the general activity category the daily routine activities such as cooking, cleaning, childcare, sitting, reading, talking, shopping, dressing, etc were included. Rural activities included activities such as chopping wood, hunting, farming, milking the cows, setting up the fence and so on. About 19.41% of the women participated in leisure time physical activity and 21.02% had exercised in the fourth month.

On average, pregnant women spent 4 hours and 40 minutes in the fourth month in non-stationary activity such as walking, compared to 4 hours and twenty minutes in the seventh month. The physical activity patterns of the mother during the fourth month and seventh month of pregnancy, as calculated from their activity diaries are shown in Table 10. No significant difference in the overall activity pattern was found between the fourth and seventh months of pregnancy. On average most women spent 9.9 hrs in sleeping, and only 13 minutes in high intensity activities such as exercise. Overall most women were found to be sedentary whereas some maintained their activity levels throughout pregnancy.

Table 10: Time in minutes spent in different activity categories in all subjects (n=371 at 4th month and n=310 for 7th month)

Physical activity category	Mean time (minutes)	SE Mean	Median	Q1	Q3	Range
Month 4	**N= 371**					
Sleeping	592	4.54	585	535	635	305-1115
Stationary	571	5.87	585	500	650	190-880
Moderate low	207	4.26	200	155	245	15-575
Moderate mod	57	2.91	45	20	80	0-385
High	13	1.38	0	0	15	0-205
Month 7	**N= 310**					
Sleeping	599	5.02	598	540	655	300-965
Stationary	579	6.8	590	490	660	280-990
Moderate low	199	4.4	190	144	250	10-580
Moderate mod	51	3.0	35	8.8	80	0-400
High	11	1.21	0	0	15	0-155

3.3.2 The intensity of activities

Results

The magnitude of changes with exercise during pregnancy is directly related to a host of exercise variables, predominantly among which are intensity and duration of exercise. Thus the product of intensity and duration of physical activity was calculated to give the quantitative measure of exercise performance. No significant difference in activity intensity categories was found between the 4th and 7th months of pregnancy (Table 11).

Table 11: Intensity of activity (METS) x duration of activity (minutes) for the different activity categories (n=371 at 4th month and n=310 for 7th month)

Physical activity category	Mean (MET x mins)	SE mean	Median	Q1	Q3	Range
4th month						
Sleeping	592	4.54	585	535	635	305-1115
Stationary	794	8.67	790	690	900	237-1445
Moderate low	521	10.7	500	388	613	38-1438
Moderate high	206	10.7	158	70	283	0-1470
High	67	7.27	0	0	75	0-1170
7th month						
Sleeping	599	5	598	540	655	300-965
Stationary	803	10	806	677	913	358-1378
Moderate low	499	11	475	363	625	25-1450
Moderate high	184	11	123	31	280	0-1400
High	56	6	0	0	75	0-870

3.3.3 Total energy expenditure at fourth month and seventh month

Results

The average total energy expenditure during the fourth month was found to be 2623 ± 529 kcal per day (10964 ± 2211 kJ per day). The range was 1610 kcal (6729.8 kJ) to 4671 kcal (19524.8 kJ). During the seventh month the average total energy expenditure was found to be 2713 ± 524 kcal per day (11340 ± 2190.3 kJ per day). The range was found to be 1741kcal (7277.4 kJ) to 4593 (19198.7 kJ) kcal per day. There was no significant difference between the energy expenditure in the fourth month and seventh month.

3.4 Cultural Social background of subjects and time spent in physical activity

Results

The time spent in each physical activity category shown in the table has been calculated cumulatively. This has been done in an ascending order of the number of METS spent in each activity. There are 1440 minutes in a day so when all the activity groups are added the end result will always be 1440 minutes for all ethnic groups. The high activity category has therefore been left out and not added cumulatively, as no difference would be seen between the groups. There was no significant difference in the activity patterns when ethnicity was considered. See Table 12.

The time spent in physical activity was not significantly different between the three occupational groups in the fourth month, except when the moderate low activity category was added. See (Table 13). The highest occupational group was the least sedentary. During the seventh month, the higher occupational group was again found to be the most active. The unemployed group was found to be the least active during the seventh month. All these results were significant.

The urban women were found to be more sedentary than the rural women during the fourth month of pregnancy. This result was almost significant ($p < 0.1$). However, on average the rural women were found to sleep more than the urban women during the fourth month of pregnancy. This difference was found to be significant ($p < 0.05$). See Table 14. No significant difference in the activity levels was found during the seventh month of pregnancy.

No significant difference in the time spent in physical activity was found in the different income groups during the fourth month of pregnancy. See Table 15. In the seventh month of pregnancy, those earning less than NZ $15,000 were found to be the most sedentary. No significant difference with training was found in the activity patterns in the pregnant women in this study.

Table 12: Time spent in minutes on physical activity by ethnicity (n=371)

Physical activity category	European (n=303)	Maori (n=45)	Pacific Islanders (n=23)
Month 4	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**
Sleeping	587 ± 4.0	610 ± 20	609 ± 22
Sedentary	1164 ± 6	1151 ± 17	1168 ± 24
Moderate low	1369 ± 4	1371 ± 10	1386 ± 15
Moderate mod	1427 ± 2	1430 ± 4	1432 ± 5
Month 7			
Sleeping	595 ± 5	615 ± 18	612 ± 21
Sedentary	1176 ± 6	1198 ± 16	1156 ± 30
Moderate low	1375 ± 4	1379 ± 11	1393 ± 11
Moderate mod	1427 ± 2	1429 ± 4	1430 ± 6

Table 13: Time in minutes spent in physical activity by occupational status. (n=371)

Physical activity category	Group1 (n=168)	Group2 (n=175)	Group3 (n=28)	P value
Month 4	Median	Time in	minutes	
Sleep	580	585	595	0.241
Sedentary	1160	1180	1190	0.230
Moderate low	1370	1390	1398	0.000*
Moderate mod	1440	1440	1440	0.061
Month 7				
Sleep	590	595	660	0.042*
Sedentary	1170	1185	1225	0.044*
Moderate low	1380	1400	1420	0.000*
Moderate mod	1440	1440	1440	0.002*

* $p < 0.05$

Table 14: Time in minutes spent in physical activity by location (n=504)

Physical activity category	Urban n=372	Rural n=131	P value
Month 4			
Sleep	580	600	0.018*
Sedentary	1180	1140	0.057
Moderate low	1380	1380	0.535
Moderate mod	1440	1440	0.449
Month 7			
Sleep	580	600	0.627
Sedentary	1180	1165	0.499
Moderate low	1390	1395	0.829
Moderate mod	1440	1440	0.843

*p<0.05

Table 15: Time spent in minutes in physical activity during the fourth and seventh months of pregnancy by total household income (n=366 at 4th month and 308 at 7th month)

Physical activity category	<$ 15,000	$16,000-$25,000	$26,000-$35,000	>$ 35,000
Month 4	**Mean**	**Number**	**of**	**Minutes**
Number	**16**	**26**	**41**	**283**
Sleeping	614 ± 23	610 ± 23	612 ± 13	585 ± 5
Sedentary	1174 ± 28	1185 ± 18	1140 ± 13	1165 ± 6
Moderate low	1365 ± 16	1385 ± 10	1366 ± 8	1371 ± 4
Moderate mod	1423 ± 9	1434 ± 5	1431 ± 3	1427 ± 2
Month 7				
Number	**18**	**26**	**32**	**232**
Sleeping	693 ± 37	603 ± 18	591 ± 11	592 ± 5*
Sedentary	1211 ± 28	1206 ± 21	1126 ± 21	1179 ± 6*
Moderate low	1399 ± 16	1394 ± 10	1358 ± 14	1375 ± 4*
Moderate mod	1431 ± 5	1436 ± 2	1423 ± 9	1427 ± 2

*p<0.05

3.5 Physical activity intensity in METS and the socio-cultural background of subjects

Results

The intensity of physical activity in the different occupational groups has been calculated cumulatively and has been shown in Table 16, and in the different ethnic groups in Table 17. In the fourth month of pregnancy the middle occupational group spent more time on intense moderate low exercise. This result was significant at 95% confidence interval. The higher occupational group was found to be the most active. This result was also significant. This trend was also seen in the seventh month of pregnancy.

There were no significant ethnic differences in the physical activity intensity categories except in the seventh month. The Pacific People were found to be more involved in moderate low intensity activities in the seventh month and the Maori women the least.

The cumulative differences in physical activity intensity with income are shown in Table 18. When the physical activity intensities were compared in the different income groups in the study, it was found that several significant differences existed. In the fourth month of pregnancy those earning less than NZ $25,000 were found to be less active and those earning above NZ $35,000 were found to be the most active. In the seventh month, it was observed that those earning between NZ $26,000 to NZ $35,000 were found to be the most active and least sedentary.

The cumulative physical activity intensities were compared with the educational qualifications of the subjects. Overall in the fourth month and seventh month there was no significant difference in the time and intensity of activities performed by the mothers with regard to the type of training they had had. (See table 19) However, in the fourth month of pregnancy, those with university education were the most sedentary.

Table 16: Cumulative physical activity intensity in METS by occupational groups (n=371 for 4th month, n=310 for 7th month)

Physical activity category	Group1	Group2	Group3	P value
Month 4	**Mean time in minutes × intensity**			
Number	**168**	**175**	**28**	
Sleep	586	592	621	0.241
Sedentary	1382	1387	1402	0.910
Moderate low	1883	1936	1861	0.001*
Moderate mod	2124	2110	2065	0.317
High	2196	2145	2099	0.020*
Month 7				
Number	**145**	**142**	**23**	
Sleep	594	597	644	0.042*
Sedentary	1396	1406	1418	0.608
Moderate low	1881	1922	1901	0.159
Moderate mod	2101	2087	1984	0.016*
High	2155	2118	1969	0.000*

* $p<0.05$

Table 17: Cumulative physical activity intensity in METS by ethnicity (n=371 in the 4 th month, n=306 in the 7th month)

Physical activity category	European	Maori	Pacific People	P value
Month 4	**Mean time in minutes × intensity**			
Number	**303**	**45**	**23**	
Sleeping	587	610	609	0.158
Sedentary	1389	1366	1378	0.516
Moderate low	1904	1916	1924	0.792
Moderate mod	2111	2135	2093	0.688
High	2183	2185	2127	0.454
Month 7				
Number	**244**	**44**	**18**	
Sleeping	595	615	612	0.407
Sedentary	1402	1417	1370	0.489
Moderate low	1902	1873	1963	0.075*
Moderate mod	2091	2055	2095	0.493
High	2144	2123	2145	0.842

*p<0.05

Table 18: Cumulative physical activity intensity in METS by total income (n=366 in the 4th month, n= 308 in the 4th month)

Physical activity category	<$15,000	$16,000-$25,000	$26,000-$35,000	>$ 35,000
Month 4	**Mean time in minutes × intensity ± SE mean**			
Number	**16**	**26**	**41**	**283**
Sleeping	614 ± 23**	610 ± 23**	612 ± 13**	585 ± 5**
Sedentary	1358 ± 33*	1424 ± 31*	1370 ± 17*	1390 ± 9*
Moderate low	1841 ± 38**	1922 ± 34**	1934 ± 19**	1907 ± 9**
Moderate mod	2052 ± 63	2097 ± 41	2164 ± 26	2109 ± 12
High	2146 ± 63	2132 ± 40	2212 ± 30	2179 ± 12
Month 7				
Number	**18**	**26**	**32**	**232**
Sleeping	693 ± 37*	603 ± 18*	591 ± 11*	592 ± 5*
Sedentary	1369 ± 37	1426 ± 26	1359 ± 28	1409 ± 9
Moderate low	1842 ± 38	1905 ± 25	1939 ± 27	1900 ± 9
Moderate mod	1958 ± 53	2056 ± 40	2171 ± 33	2089 ± 12*
High	2001 ± 63*	2087 ± 47*	2222 ± 44*	2147 ± 13*

*p<0.05; **p<0.001

Table19: Cumulative intensity of exercise during the fourth and seventh month of pregnancy by educational status. (n=371 in the 4th month, n=301 in the 7th month)

Physical activity category	University	Technical institute/other	Job training/no training
Month 4	**Mean time in minutes × METS ± SE Mean**		
Number	**92**	**177**	**102**
Sleeping	578 ± 8	599 ± 7	592 ± 9
Sedentary	1426 ± 13	1366 ± 12	1385 ± 13*
Moderate low	1908 ± 12	1899 ± 12	1918 ± 13
Moderate mod	2123 ± 19	2117 ± 16	2096 ± 18
High	2180 ± 21	2192 ± 16	2159 ± 20
Month 7			
Number	**n=85**	**n=139**	**n=86**
Sleeping	596 ± 9	600 ± 8	601 ± 10
Sedentary	1408 ± 14	1396 ± 12	1406 ± 17
Moderate low	1910 ± 14	1891 ± 12	1908 ± 17
Moderate mod	2097 ± 18	2090 ± 17	2070 ± 20
High	2151 ± 22	2140 ± 19	2133 ± 25

*$p<0.05$

3.6 Energy expenditure and the socio-cultural background of subjects

Results

The total energy expenditure in the fourth month of pregnancy differed by race with the European's spending the least, and the Pacific peoples the most energy. These results were highly significant ($p<0.001$). See table 20. The rural women spent more energy (2497.9± 562 kcal per day) than the urban women (2363±522.3 kcal per day) in the fourth month. The same trend was seen in the seventh month. The urban women spent 2658.3 calories and the rural women spent 2925.3 calories. Both the results were significant. In the fourth month, no difference in energy expenditure was found when subjects were analyzed by income group. However, in the seventh month those earning over NZ $ 26,000 were found to be the most active than the lower income earners ($p< 0.03$). See table 21. When training was used as a factor it was found that those who were technically trained were the most active, and the university trained were the least active. See table 22. No significant difference in energy expenditure in sedentary activities was found in the occupational groups until the moderate low activity expenditure was added. The lower occupational group was found to spend the least energy in moderate low activity.

Table 20: Total energy expenditure by ethnicity (n=371 in the 4th month, n= 308 in the 7th month)

Total energy expenditure	European	Maori	Pacific people	P value
Month 4	2354.5	2469.5	2801.0	0.001*
Month 7	2656.6	2860.3	3133	0.000*

*p<0.01

Table 21: Total energy expenditure by total income (n=371 in the 4th month, n=308 in the 7th month)

	<$15,000	$16,000-$25,000	$26,000-$35,000	>$35,000	Don't know	
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	P value
Month 4	2700±331	2600±631	2800±697	2595±498	2621±436	0.23
Month 7	2528±143	2521±133	2865±199	2653±152	2402±107	0.03*

*p<0.01

Table 22: Total energy expenditure by training (n=371 in the 4th month, n=308 in the 7th month)

	University	Polytech	Job training/no training	
	Mean±SD	Mean±SD	Mean±SD	P value
Month 4	2513.7±451.9	2683.9±560.1	2614.3±525.1	0.04*
Month 7	2661.9±492.2	2710.5±534	2767.2±539.8	0.42

*p<0.05

Chapter four: Analysis of maternal medical issues during birth and activity levels

Two hundred and twenty eight women were followed up after pregnancy in order to study the impact of physical activity levels on the course and outcome of pregnancy. The results are presented in the following section.

4.1 Medical problems during pregnancy

Results

Gestational diabetes was present in 2.6% of the study sample. While 16.2% had high blood pressure during pregnancy, 5.3% had toxaemia, and 36.4% had edema. Iron deficiency was present in 38.1% of the population. Pregnancy associated asthma was present in 7.5% of the study sample.

About twelve percent of the women followed up after pregnancy were hospitalised during pregnancy, for various reasons. These are shown in Table 23.

Table 23: Reasons for hospitalising women in the study sample and percentage hospitalised. (n=23)

Reasons for hospitalisation	Percentage of total subjects
Number of subjects	**23**
Threatened abortion	0.60%
Morning sickness	0.99%
Premature labor	1.19%
Accident (Fall)	0.40%
Deep vein thrombosis	0.20%
Absence of fetal movement	0.20%
Hypoglycemia	0.20%
Tachycardia	0.20%
Other causes	1.20%

4.2 The impact of physical activity on birth interventions

Results

In 63% of the subjects, labor started naturally, in 21% labor was induced and in 8%, labor started naturally and then stopped and had to be induced. Seven percent of the women in the study had an elective caesarean.

Birth interventions were categorized as follows: forceps, Caesarean section, episiotomy and venteuse. Out of the total study sample, 56.6% of the women needed no birth intervention. Most women required more than one form of birth intervention. Those needing only one birth intervention comprised about 32.9% of the sample, and 9.2% needed two interventions. Another 1.3% needed three interventions during birth. On calculating the percentage requiring the different types of birth interventions, it was found that forceps were used on 7.9%, 21.1% had a Caesarean section, 20.6% needed an episiotomy and 5.7%, venteuse.

Urban women needed more birth interventions as compared to rural women. (See Table 24). Almost 25% of urban women needed Caesarean sections as compared to only 7.7% of rural women. The percentage of women requiring birth interventions in each ethnic group is shown in Table 25. No significant differences in the need for birth interventions were found with ethnicity. Since the numbers of Maori and Pacific pregnant mothers were too small to carry out analysis effectively, these two groups were combined and a chi-square analysis was done to see if there was any difference in the need for birth interventions. No significant differences were seen between any of the groups. Moreover, a two-sample test was also done, which again showed no real difference between the ethnic groups.

When a regression analysis was done to see if there was any impact of physical activity on the need for birth interventions, a significant relationship between sedentary activity during the fourth month and the need for birth intervention was found. Table 26 shows the percentage of women requiring birth intervention in the fourth month according to the tertile of sedentary activity. These results are especially significant for the need for episiotomy. Only 12.3% of women in the lower tertile who spent lesser time in sedentary activity needed an episiotomy as compared to 28.1% and 23.1% women in the upper two tertiles. As the number of minutes spent in sedentary activity increased, the percentage of women needing Caesarean section also increased. However, this result was not significant.

The need for pain relief was calculated and it was observed that 22.4% needed no pain relief, 37.3% needed one type of pain relief, 25.9% needed two types, 11.4% needed three types and 3.0% needed four types of pain relief. Different types of pain relief were used, such as 27.2% were given syntocin, 20.2% were given pethedine, 38.6% used gas, 35.0% were given an epidural, 13.2% used other pain relief such as arnica, tens machine, and other herbal remedies, and 1.0% didn't know what sort of pain relief they used. The percentage of urban and rural women needing pain relief is shown in Table 27. It was found that almost 79.5% of urban women needed some form of pain relief compared to 71% of rural women ($p<0.01$). There were significant differences between the urban and rural women in the need for syntocin, epidural and other forms of pain relief.

A regression analysis was also done to see if there was any relationship between physical activity and the need for pain relief. This revealed that women spending more time in moderate high activity in the fourth month were found to require lesser pain relief. See Figure 1. Table 28 shows that only 18.5% of the women needed syntocin when they spent 70 to 305 minutes in moderate high intensity activities as compared to 36.4%, when they spent only 0-30 minutes in this activity category i.e. almost double the number of women needed syntocin. The need for epidural was almost halved when the time spent in moderate high activity increased from 0-30minutes to 70-305 minutes per day. No significant relationship was found between the total energy expenditure at fourth month and total pain relief and type of labor.

Table 24: Percentage of women needing birth intervention by location (n= 228)

Type of intervention	Rural (%)	Urban (%)	P value
Number	52 (23%)	176 (77%)	
Forceps	9.62	7.39	0.600
C-section	7.69	25.00	0.007*
Episiotomy	23.08	19.89	0.617
Venteuse	1.92	6.82	0.181

*$p<0.05$

Table 25: Percentage of women needing birth intervention by ethnicity (n=228)

Type of intervention	European (%)	Maori (%)	Pacific People (%)	P value
Number	183	33	12	
Forceps	7.65	6.06	16.67	*
Caesarean section	22.95	15.15	8.33	0.324
Episiotomy	21.86	15.15	16.67	0.641
Venteuse	6.01	3.03	8.33	*

***Numbers were too small within the racial categories to reliably carry out a chi-square test.**

Table 26: Percentage of women needing birth interventions according to tertile of sedentary activity (month 4) (n=194)

Birth intervention	Tertile 1 830-1130 min in sedentary activity n=65	Tertile 2 1130-1210 min sedentary n=64	Tertile 3 1210-1345 min sedentary n=65	Total	P value
Forceps	6.2 %	6.3 %	9.2 %	7.2 %	0.743
Caesar	13.9 %	20.3 %	24.6 %	19.6 %	0.290
Episiotomy	12.3 %	28.1 %	23.1 %	21.1 %	0.080*
Venteuse	6.2 %	4.7 %	7.7 %	6.2 %	0.778

*p< 0.1

Table 27: Percentage of women needing pain relief by location (n=228)

Type of pain relief	Rural (%)	Urban (%)	P-value
Syntocin	17.31	30.11	0.068**
Pethedine	15.38	22.16	0.289
Gas/air	44.23	36.93	0.342
Epidural	25.00	38.07	0.083**
Other	5.77	15.34	0.073**

**p<0.1

Figure 1.

n=194

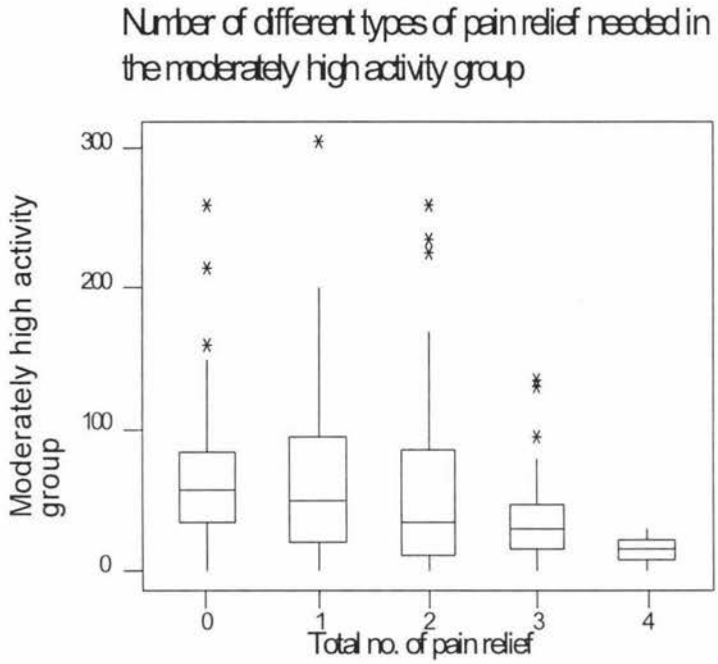


Table 28: Percentage of women needing pain relief according to tertile of moderate high activity (month 4) (n=194)

Type of pain relief	Percentage of subjects in tertile 1 Range=0-30 minutes	Percentage of subjects in tertile 2 Range=30-70 minutes	Percentage of subjects in tertile 3 Range=70-305 minutes	Total	P value
Number	65	64	65	194	
Syntocinin	36.9	25.0	18.5	26.8	0.055**
Pethidine	30.8	15.6	15.4	20.6	0.046*
Gas/air	40.0	29.7	44.6	38.1	0.203
Epidural	47.7	34.4	21.5	34.5	0.007***
Other	15.4	9.4	18.5	14.4	0.328

*$p<0.05$, **$p<0.1$, ***$p<0.01$

4.3 Effect of physical activity on length of labor

Results

The mean length of labor was calculated to be 10 hrs and 45 minutes. There was no significant difference by ethnicity or occupational status in the length of labor. About 1.32% of the women that were followed up after pregnancy, were found to need drugs to stop labor as the baby was born premature. The length of labor was affected by the amount of time women spent in physical activity during their pregnancy. Figures 2 and 3 show the effect of time spent in stationary activity and sleeping on the length of labor. The more time they spent in sedentary activity in the seventh month, the longer was the labor. On the other hand, the longer they slept in the seventh month, the shorter the duration of labor. When intensity of the physical activity was included in the calculation, length of labor was not affected. Figure 4 shows the effect of log of time spent in sleeping on the length of labor.

Figure 2: (n=194)

The impact of duration of stationary activity in the seventh month of pregnancy on length of labor

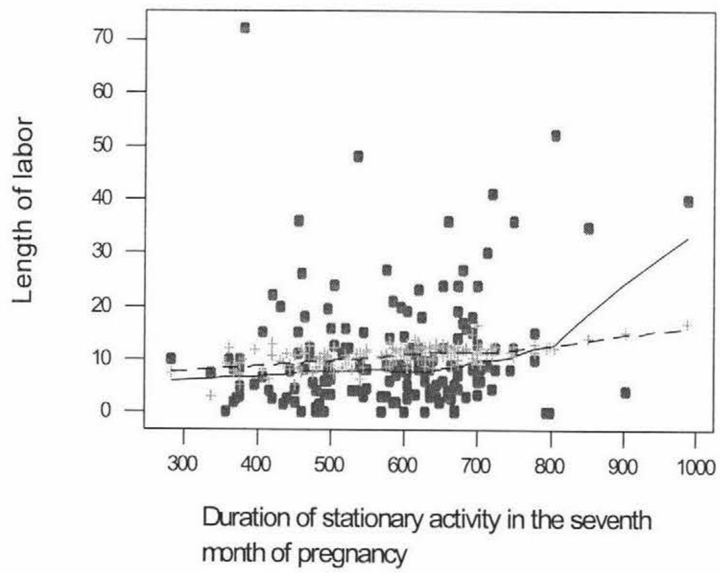


Figure 3: (n=194)

The impact of length of time spent sleeping during the seventh month on length of labor

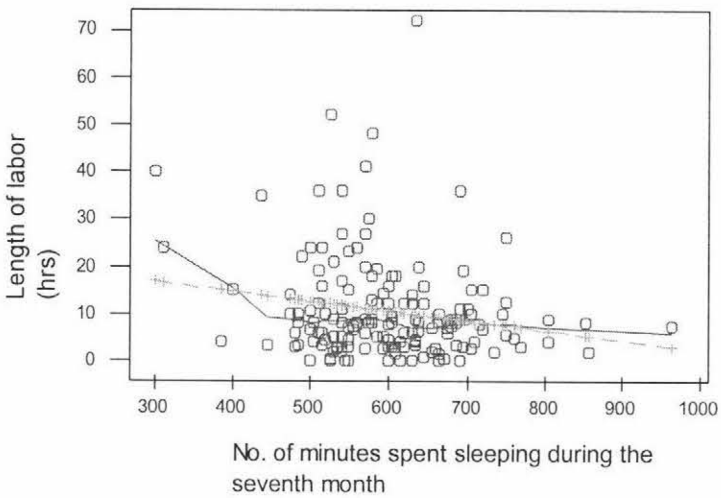
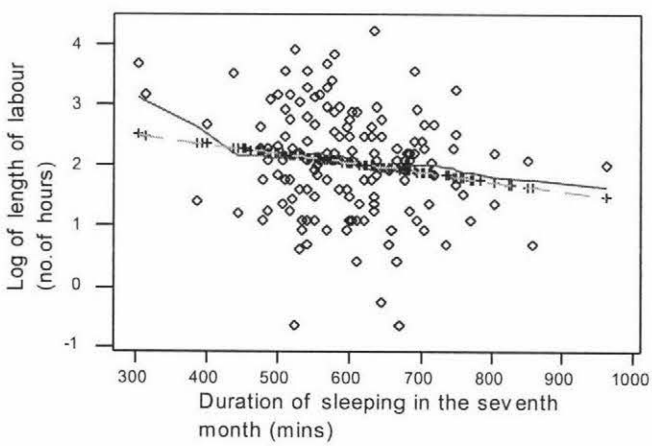


Figure 4: (n=194)

Log of length of time spent sleeping during the 7th month and its effect on duration of labor



4.4 Impact of physical activity on gestational age

Results

The average gestational age of infants born in this study was calculated to be 278.8 ± 13.38 days. The range was between 176 to 323 days. On grouping the women in the study on the basis of the number of days born premature or over due, it was found that 4.6% were born more than twenty-two days premature; 5.1% arrived fifteen to twenty-one days early; 86.6% arrived on time; 2.0% were born fifteen to twenty-one days late and 1.7% were born more than twenty-two days over the due date. The mean difference between the expected date of birth and the actual date of birth was calculated to be -1.175 ± 13.38 days. In other words the infants were born almost one day earlier to thirteen days late.

There was no significant difference in gestational age of infants born in this study by ethnicity. However, the difference in gestational age by location was weakly significant ($p<0.1$). See Table 29.

A regression analysis was done to see if physical activity had any impact on the gestational age of the babies. The results were found to be significant only for time spent in sedentary activity. A two sample-test was carried out to see if the difference in means of the upper and lower quartiles was significant. See Figure 5. This technique was used for exploratory purposes only. The more sedentary people bore infants with a shorter gestational age and the more active the subjects the more likely they were to go full term.

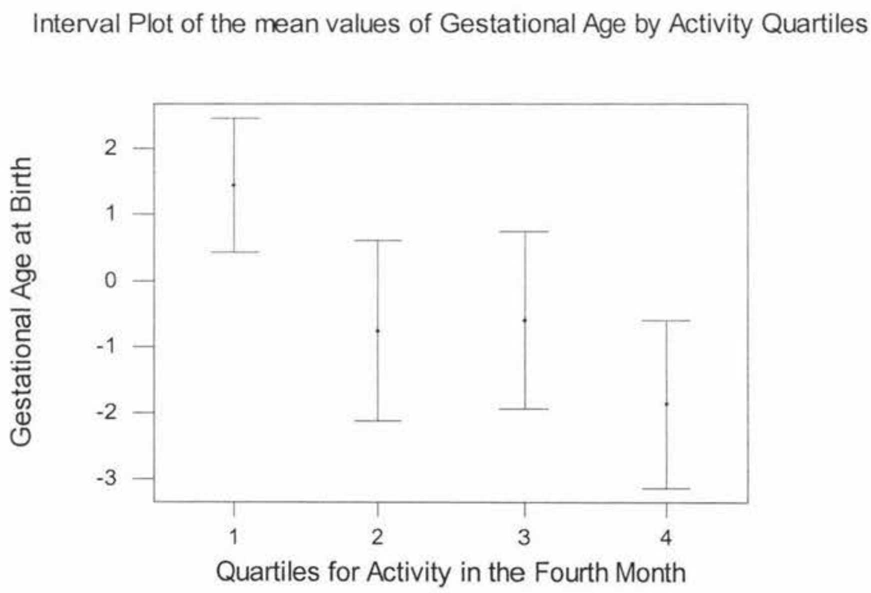
Sixty-nine infants, i.e. 17.87% were large-for-gestational age (>4000g) and 16 infants, i.e. about 3.91% were small-for-gestational age (<2500g). Of those born large, 2.74% were premature, 86.3% were born on time, 5.48% were born fifteen to twenty-one days later than due date and 5.48% were more than twenty-two days over the due date. Of those born small, 37.5%

arrived more than twenty-two days premature, 31.3% arrived fifteen to twenty-one days premature and 31.2% were born at term.

Table 29: Gestational age of the babies by location (Rural n=102, Urban n=309)

Location	Mean (days)	S. D. (± days)	Range (days)
Rural	280.36	18.71	176-323
Urban	278.31	11.06	216-296

Figure 5 : Impact of time spent in sedentary activity by gestational age.(n= 371)



Activity Quartiles: 1 = 0 to 1114 minutes
2 = 1115 to 1174 minutes
3 = 1175 to 1234 minutes
4 = 1235 to 1440 minutes

4.5 Impact of physical activity on health of the baby

Results

The birth weight, length and head circumferences of the babies by sex are given in Table 30. The boys were heavier as well as longer than the girls. Their head circumference was also greater than that of the girls.

The anthropometric measures of the baby by occupational status and ethnicity are shown in Tables 31 and 32 respectively. There was no significant difference in the birth measures of the baby by ethnicity or occupational status.

Low birth weight defined as in the ninth revision of the International Classification of Diseases as a birth weight below 2500 g (165) was calculated to reveal that 3.91% of the babies in this study were of low birth weight. Out of these low birth weight babies, 81.25% were European, 12.5% were Maori and 6.25% were Pacific Islanders.

Of the 228 infants followed up after pregnancy, it was found that about 21 of the infants (9.2%) had needed special care in a neonatal unit after birth. The length of stay in the special care unit was found to be on average about one day. The range was between 0 to 42 days. No relationship between time spent in physical activity and the length of stay was found. Table 33 shows the reasons for their hospitalisation. A significant relationship was found between birth weight and those needing special care after birth. Those needing special care weighed on average 615.4g less than those that did not.

No significant association was found between length of physical activity at fourth and seventh months and newborns needing special care after birth. A weak relationship was seen between Apgar scores at 1 minute and sedentary activity at the fourth month of pregnancy ($p<0.1$). The less the time spent in sedentary activity the higher the Apgar score. No significant relationships were seen between Apgar scores at five minutes and physical activity in the fourth and seventh months of pregnancy.

Table 30: Anthropometric measures of the baby. (n=200 boys, n=214 girls)

	Boys (n=200)		Girls (n=214)	
	Mean ± SD	Range	Mean ± SD	Range
Weight	3621.5 ± 574.1	1710-5450	3415.3 ± 597.1	1190-5140
Length	52.73 ± 4.2	42.30-59.1	51.31 ± 2.72	38.0-59.0
Head circumference	35.37 ± 1.73	29.0-40.6	34.63 ± 1.64	27.0-39.0

Table 31: Weight, length and head circumference of the baby by occupational status (n= 414)

Infant measures	Group 1	Group 2	Group 3
Number	175	206	33
	Mean ± SE mean		
Weight (g)	3543 ± 44.5	3495 ± 42	3486 ± 106
Length (cm)	52.3 ± 0.3	51.8 ± 0.2	51.3 ± 0.6
Head circumference (cm)	35 ± 0.11	35 ± 0.13	34.4 ± 0.38

Table 32: Infant measures by ethnicity (n=414)

Infant measures	European	Maori	Pacific People
Number	325	64	25
	Mean ± SE mean		
Weight (g)	3524.8 ± 32.6	3420.5 ± 70.5	3626 ± 147
Length (cm)	51.95 ± 0.2	52.15 ± 0.4	52.77 ± 0.8
Head circumference (cm)	34.97 ± 0.1	34.97 ± 0.3	35.35 ± 0.4

Table 33: Infants needing special care after birth (n=21)

Reason for special care	Percentage of those needing special care
Breathing difficulty	19.2
Hypoglycemia	14.4
Pneumonia	4.8
Cord entanglement	4.8
Meconium staining	4.8
Low Apgar score	14.4
Heart murmur	4.8
Prematurity	33.6

4.5.1 Factors affecting the birth weight of the baby

Results

The impact of the location, occupational status, ethnicity, income level and education on birth weight is shown in Table 34. No significant difference in the birth weight of the babies was found with any of these factors.

The results of the regression analysis to see if there was any impact of the anthropometric measures of the mother on infant measures are presented in Table 35. Weight before pregnancy, weight at fourth month of pregnancy, weight at seventh month of pregnancy, height of the mother, triceps and costal skinfold thicknesses at fourth month, biceps, triceps and costal skinfold thicknesses at seventh month were all significant.

The BMI of the mother before pregnancy and at the seventh month of pregnancy, had a significant impact on the birth weight of the baby. See Table 36.

No significant effect of time spent in the different physical activity categories was found on the birth weight of the baby. Even when intensity of the activity was included, no significant effect on the birth weight of the baby was seen.

Table 34: Impact of location, sociogroup, ethnicity, income level and education on birth weight (n=414)

	Coefficient	R sq	P value
Sociogroup	-71.64	0.1%	0.281
Location	-18.76	0.0%	0.850
Education	-89.19	0.6%	0.124
Income	-2.07	0.0%	0.957
Race	-30.00	0.0%	0.696

Table 35: Impact of anthropometric measures of the mother on the birth weight of the baby (n=414)

Anthropometric measures	Coefficient	R-sq(adj)	P value
Weight before pregnancy	7.753	2.9%	0.000*
Weight at 4th month of pregnancy	6.504	2.0%	0.003*
Weight at 7th month of pregnancy	10.464	6.4%	0.000*
Height	19.624	3.8%	0.000*
Biceps skinfold thickness at 4th mo	3.214	0.0%	0.392
Triceps skin fold thickness at 4th mo	9.040	1.0%	0.023*
Costal skinfold thickness at 4th mo	10.010	1.1%	0.021*
Biceps skinfold thickness at 7th mo	10.033	1.6%	0.007*
Triceps skin fold thickness at 7th mo	13.825	2.9%	0.000*
Costal skinfold thickness at 7th mo	16.133	3.5%	0.000*

*P<0.05

Table 36: Impact of BMI (pre-pregnancy, fourth and seventh months) on birth weight of the baby. (n=414)

	Co-efficient	R^2 (%)	P value
BMI (weight before pregnancy)	14.255	1.1	0.022*
BMI (4th month)	8.763	0.3	0.140
BMI (7th month)	19.504	2.7	0.001*

*$p<0.05$

Chapter five: Effect of physical activity on weight gain

5.1 Weight change during the fourth month of pregnancy and physical activity

Results

For this analysis, the effect of sleeping, stationary, walking, housework, leisure, exercise and sports were considered in the form of cumulative variables. A regression analysis between time in minutes spent in physical activity and weight gain during the fourth month showed a weak relationship between sedentary activity and weight change. ($p<0.1$) See Table 37.

The intensity of physical activity in the fourth month regressed against the weight change during the fourth month showed a weak relationship. See Table 39.

5.2 Weight change between the fourth and seventh month of pregnancy and physical activity

Results

Every minute spent in sleeping and sedentary activity during the fourth month led to a weight gain of 0.0052 kilograms of body weight between the fourth and seventh month of pregnancy ($p<0.05$). See Table 37. In the fourth month, time spent in moderate high activity and moderate low to moderate high categories combined led to weight loss of 0.00718 and 0.00488 kilograms respectively ($p<0.05$). See Table 37.

Time spent in sedentary activity in the seventh month showed a strong relationship with weight gain during the fourth to seventh months of pregnancy. The women were found to gain 0.00444 kilograms with every extra minute spent in sedentary activity. Weight loss of 0.00637 kilograms was also seen with every minute spent in moderate high activity. Even when the moderate low to moderate high categories in the seventh month were combined, weight loss of 0.00464 kilograms was observed. See Table 38.

The product of intensity of physical activity and its duration which is a quantitative measure of exercise performance was also used to see if this has any effect on weight change during the fourth to seventh months. Thus when the activity intensity categories were considered, a strong relationship was seen between the two. See Table 39. For every minute spent sleeping in the fourth month, the weight increased by 0.0052 kilograms between the fourth to seventh month of pregnancy. With every minute spent in sedentary activity, the weight increased by 0.0025 kilograms. Activity of moderate high intensity during the fourth month led to a weight loss of 0.0026 kilograms. However, high intensity activity during the fourth month surprisingly led to a weight gain of 0.0026 kilograms.

In the seventh month of pregnancy, with every minute spent in sedentary activity, a weight gain of 0.0026kg was seen. Weight loss of 0.0020kg was seen with every minute spent in moderate high intensity category. Moreover, with every minute spent in high activity category, a weight loss of 0.0014 kg per minute was observed. See Table 40.

5.3 Postpartum weight retention and physical activity during pregnancy

Results

The weight of the mother after birth of the baby was noted down during the telephonic follow-up interview. Since the weights obtained from the mothers after birth were all at different lengths of time after birth, ranging from 0 to 15 months, a plot of weight retention by time in months postpartum was done to see if the relationship was linear over time. See Figure 6. There is no slope and therefore, it was concluded that time makes no difference to the mother's postpartum weight.

No significant effect of time spent in physical activity during the fourth or seventh month of pregnancy was found on the postpartum weight retention. However, the time spent in sedentary to moderate low intensity activity in the fourth month of pregnancy, was almost significantly related to the weight retained postpartum ($p<0.1$). When the intensity of physical activity in the seventh month was regressed against postpartum weight retention no relationship was seen between the two. See Table 40.

Figure 6: n=157

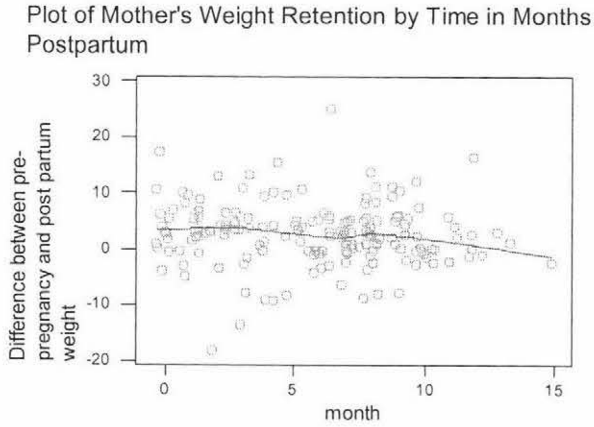


Table 37: Effect of time (minutes) spent in physical activity in the fourth month (Mo4), on weight change in the fourth month, seventh month (Mo7) and postpartum (pp).(n=157 in the 4th month and 138 in the 7th mo)

Physical activity category	Weight change (Mo4-Mo0)			Weight change at 7th month (Mo7- Mo4)			Weight change post partum (pp wt - Mo0)		
	Co-eff	S.E mean	P value	Co-eff	S.E. mean	P value	Co-eff	S.E. mean	P value
Sleeping	-0.0024	0.0027	0.372	0.0052	0.0018	0.004**	0.0051	0.0054	0.346
Sedentary	-0.0044	0.0023	0.056*	0.0052	0.0015	0.001**	-0.0009	0.0040	0.820
Moderate high	-0.0004	0.0042	0.915	-0.0071	0.0028	0.012**	-0.0127	0.0073	0.084 *
Moderate low+high	0.0033	0.0023	0.150	-0.0048	0.0015	0.002**	0.0014	0.0040	0.721

*p<0.1, ** p<0.05

Table 38: Impact of time (minutes) spent in physical activity during the seventh month (Mo7) on weight change during the seventh month, and postpartum weight change. (n=138)

Physical activity category	Weight change at 7th month (Mo7-Mo4)			Weight change (pp wt-Mo0)		
	Co-eff	S.E. Mean	P value	Co-eff	S.E. Mean	P value
Sleeping	0.00008	0.001958	0.966	0.00372	0.00427	0.385
Sedentary	0.00444	0.00168	0.009*	0.00123	0.00427	0.774
Moderate high	-0.00637	0.00318	0.047*	-0.00582	0.00794	0.465
Moderate low +high	-0.00464	0.00180	0.010*	-0.00195	0.00462	0.674

* $p<0.05$

Table 39: Effect of intensity of physical activity during the fourth month on weight change during pregnancy. (n= 157)

Physical activity category	Weight change (Mo4-Mo0)			Weight change (Mo7-Mo4)			Weight change (pp wt-Mo0)		
	Co-eff	R^2 %	P value	Co-eff	R^2 %	P value	Co-eff	R^2 %	P value
Sleeping	-0.0024	0.0	0.356	0.0052	2.1	0.004**	0.0051	0.0	0.345
Sedentary	-0.0032	0.8	0.050*	0.0025	1.0	0.036**	-0.0022	0.0	0.408
Moderate low	0.0011	0.0	0.484	-0.0010	0.0	0.324	0.0047	0.9	0.120
Moderate high	-0.0005	0.0	0.669	-0.0026	2.8	0.001**	-0.0014	0.0	0.510
High	0.0020	0.6	0.073*	0.0026	3.3	0.000**	-0.0011	0.0	0.614

* $p<0.1$ ** $p<0.05$

Table 40: Effect of intensity of physical activity during the seventh month on weight change during pregnancy. (n=138)

Physical activity category	Weight change (Mo7-Mo4)			Weight change (pp wt-Mo0)		
	Co-eff	R^2%	P value	Co-eff	R^2%	P value
Sleeping	0.0027	0.0	0.889	0.0040	0.0	0.347
Sedentary	0.0026	1.2	0.031**	0.0010	0.0	0.740
Moderate low	-0.0001	0.0	0.883	0.0010	0.0	0.735
Moderate high	-0.0020	1.4	0.024**	-0.0009	0.0	0.686
High	-0.0014	0.8	0.064*	-0.0002	0.0	0.886

*p<0.1, ** p< 0.05

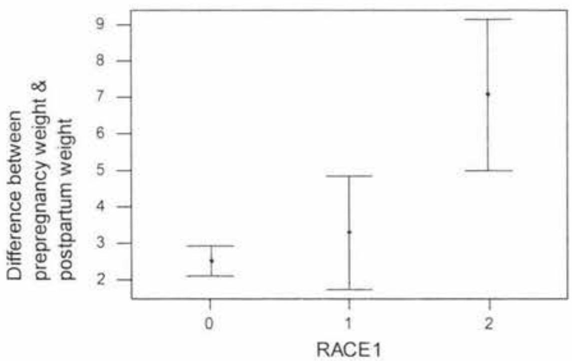
5.4 Socio-cultural background of subjects and weight retained postpartum

Results

A significant relationship between weight retained postpartum and ethnicity was found with the Pacific People retaining the most weight (z>1.96). See Figure 7. There was no significant difference in the postpartum weight retention in the occupational groups, but the higher occupational group retained the most weight, whereas the lowest occupational group had no weight retention.

No significant difference between weight retained postpartum and income or educational status was found.

Figure 7: Weight retained postpartum versus ethnicity (n=157)



0= Europeans
1= Maori
2= Pacific

Chapter six: Discussion of results from the analysis of body composition changes and activity levels during pregnancy

6.1 Cultural and occupational background of subjects

Discussion

New Zealand has an ethnically diverse population. In 1996, the Maori ethnic group made up about 15.1% of the total population and Pacific people a further 5.8% (140). In this study, the Maori and Pacific mothers were over-sampled as requested by the Ministry of Health. Moreover, in 1996, 86% of the New Zealand population lived in the urban areas, and in this study, about 14% of the subjects studied lived in urban areas (140). Therefore, the study sample in terms of the percentage living in the rural and urban areas is fairly representative of the population distribution.

A cross tabulation of training with occupational group revealed that 35% of university qualified subjects were found to belong to the higher occupational group and 48% with technical qualifications belonged to the middle occupational group. Health outcomes vary according to the social and economic circumstances in New Zealand. This means that while overall health outcomes may be improving, the health outcomes for some particular segments of the population may actually be static or even worsening. A cross tabulation of ethnicity with the occupational group was done. This revealed that 24.8% of Maoris were unemployed compared to 15.6% Pacific people and 5.9% Europeans. The results in this study are consistent with the national statistics in the 1994 survey (140), wherein 22.9% of Maoris were found to be unemployed, 22.1% of Pacific people were unemployed and only 7% Europeans were unemployed. Thus the most underprivileged group in New Zealand is the Maori as the unemployment rate is the highest. Therefore it will be interesting to see the pregnancy outcome for these groups.

6.2 Anthropometric measurements of the subjects

Discussion

Prepregnancy weight for height is a determinant of gestational weight gain (141). Recent studies indicate that 23 to 38% of women with low and normal body mass index have low prenatal weight gain (84,142,146). Low pregravid BMI is associated with an increase in the prevalence of preterm delivery and spontaneous abortion among black and white women (142). On average, even women who are overweight at conception, i.e. women whose BMI exceeds 26.0, gain less weight during pregnancy than do thinner women (141,146). Women with large gestational weight gains are at an increased risk for high-birth-weight infants, which can secondarily lead to dysfunctional labor, midforceps delivery, ceasarean delivery, shoulder dystocia, meconium aspiration, and asphyxia. However, there is wide variation in weight gain by women with normal pregnancies, within each prepregnancy weight-for-height category. The variation is highest among obese women (BMI>29.0).

The average New Zealand woman has a BMI of 24.8 (140). This average is at the top end of the current recommended healthy weight range. In this study when the BMI of the European women was calculated, the average BMI was found to be 23.4. This means that the average European women in this study were in the healthy weight range. The national average for obesity has been found to be 13% in European women (140). In this study, 7% of the European women were found to be obese.

The recommended healthy BMI range for Europeans cannot be applied to other ethnic groups. Other groups may have marked genetic differences in body fat deposition and relative lean body mass. Notably Maori and Pacific people are heavier than Europeans. Thus different BMI cut-off points have been used for each ethnic group in this study.

The average weight gain between 0-4 months is high probably because pre-pregnancy weight being self-reported may have been under-reported. A missing value analysis revealed that the values were not missing at random but were informative missing. Thus since the women in this study weighed more than what they reported, it is likely that the weight gain seen in the first 4 months and between 0-7 months are probably incorrect. However, the change in weight between 4-7 months is the accurate value.

Few women returned to their pre-pregnant weight after birth. On average the women were 2.8 kilograms heavier after birth than before pregnancy.

Although no significant difference in the weight gain between the different ethnic groups is seen between 0-4 months and 4-7 months, surprisingly the Pacific mothers gained the most weight between 0-7 months. The European mothers weighed the least and the Pacific mothers the most before pregnancy and this trend seems to have continued in pregnancy.

6.3 Physical activity during pregnancy

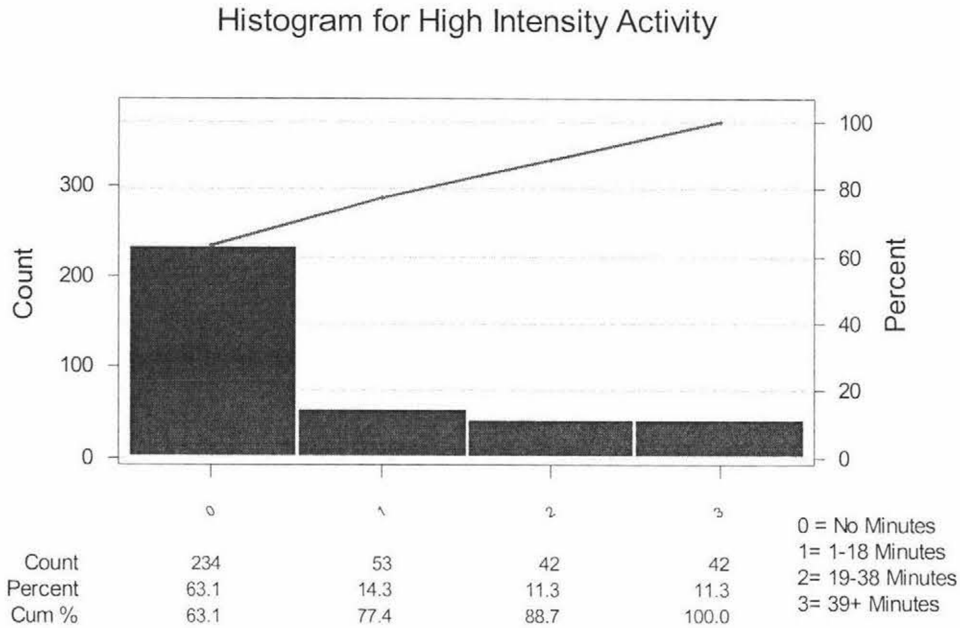
6.3.1 Time spent in minutes in different physical activity categories

Discussion

The lack of a significant difference in activity levels between the fourth and seventh months show that New Zealanders continue their normal routine throughout pregnancy. Another study by Watson, on New Zealand pregnant women found similar findings (120). As can be seen from Table 10, New Zealand women spend almost 20 hours of the day in sedentary activity which is a dangerous trend because physical activity is important for the pregnant mother as it helps prevent women from putting on excessive weight, builds and maintains strong bones, and reduces the risk of depression and anxiety. It is recommended that pregnant New Zealand women should increase their physical activity levels.

According to the Life In New Zealand Survey, about one-third of New Zealanders engage in physical activity to the level and duration recommended for cardiovascular fitness (high intensity more than twice a week and a total of at least one hour per week) (143). In the present study, 63.1% did no high intensity activity per day; 14.3% engaged in high intensity activity for 1-18 minutes per day; 11.3% for 19 to 38 minutes per day and 11.3% for more than 39 minutes per day (See Figure 8). A test of two proportions was performed to see if the proportion of women doing high intensity exercise in this study was any different to the proportion in the general population. The null hypothesis was that no real difference existed between the two populations and the alternate hypothesis was that a real difference existed. However, the results showed that the proportion of women exercising in this study was less than that in the general population ($p<0$). Therefore the null hypothesis was rejected.

Figure 8 : Percentage of subjects spending time spent in high intensity activity in the fourth month of pregnancy (n=371)



6.3.2 The intensity of activities

Discussion

Various investigators have reported that pregnant women reduce the pace and intensity of certain activities (141). Pregnant women may expend less energy per unit of time performing a task, but they take longer to complete the task. The results of the present study show that the women are doing less intense activities in pregnancy, which could have an important effect on the weight retained during pregnancy and possibly on birth outcome, as well as energy requirement during pregnancy.

6.3.3 Total energy expenditure at fourth and seventh month

Discussion

A two sample test was performed to see if there was any difference in energy expenditure between the fourth and seventh month of pregnancy. A significant difference was seen in the two mean expenditures in the fourth and seventh month, probably because of the weight gain in the seventh month causing an increased value for energy expenditure in the seventh month. Research has also shown that although activity patterns and work intensity can be adjusted to conserve energy in pregnant women, the energy expenditure of weight-bearing activity has been found to increase in most populations in proportion to weight gain (141). The impact of physical activity on the energy requirements of pregnancy depends on the proportion of time spent in such activities.

6.4 Cultural social background of subjects and time spent in physical activity

Discussion

In the calculation of these results, the cumulative variables of time spent in physical activity were considered in order to discern whether a short time spent sitting and standing corresponded to a lot of time sleeping and lying, or a lot of time doing heavy exercise.

Although in this study no significant difference in time spent in physical activity by the different ethnic groups was found, another study on New Zealand women, showed that Maori women had higher levels of intense physical activity than European women (140). Thus, the difference between the sedentary activity group and moderate low and moderate-moderate activity groups put together was calculated for this study. It was found that the Maori women in this study spent more time in higher levels of intense physical activity in the fourth month compared to the other two groups. However, in the seventh month of pregnancy the Pacific women were found to be the most active. Both these results were not significant.

The finding in the present study of a significant relationship between activity levels and occupational status are contradicted by another study that found little relation between activity levels and occupational status or residential area (140). In the seventh month, the higher occupational group was found to be the most active probably because they continued to work throughout pregnancy and beneficiaries were found to be the least active because they were not employed, and also with advancing pregnancy physical activity is further restricted.

The finding of the urban women being more sedentary could be related to the nature of their occupational activity. Rural women were mainly found to be involved in non-stationary activities such as farming, milking the cows and other physically demanding chores. Although, in the present study no significant difference in the activity pattern was found with the level of education, another New Zealand study has found people with higher levels of education participate in regular intensive exercise than those with a primary school education only (140). Education correlated significantly with pregnant women participating in vigorous activity and performing stretching exercises in yet another New Zealand study (144). A study on self-rated physical activity level during pregnancy found that women who identified their physical activity as vigorous were on an average slightly older, more educated and lighter in weight (145).

6.5 Physical activity intensity in METS and the socio-cultural background of subjects

Discussion

One MET is defined as the energy expenditure for sitting quietly, which for the average adult is approximately 3.5ml of oxygen . kg body weight -1.min -1 or 1 kcal . kg -1 body weight . h-1 (138). The time spent in physical activity was multiplied by the MET value of different activities as given in the compendium. This product was calculated to see how exercise performance was impacting on the birth outcome and maternal health. These intensity values were grouped in the same activity groups such as sleeping, sedentary, moderate-low, moderate-moderate and high.

The finding in this study that the Pacific people were more active than the Maori people, is supported by the Ministry of Health Study (140).

Although the urban women were found to be more sedentary than the rural women, there was no difference in the time spent in high intensity activities probably because the urban women nowadays are involved in recreational activities and a lot of them exercise as well.

6.6 Physical energy expenditure and the socio-cultural background of subjects

Discussion

The reason the mean energy expenditure of the Pacific people was found to be higher than that of the Europeans was either because a real difference existed in their activity levels or because the Pacific people weighed more than the Europeans. The latter seems more likely because there was no difference between the ethnic groups in the time spent in minutes in different activity categories. There is a possibility of over reporting by Pacific people as well as an interpretation bias of the levels of activity required.

The reason the urban women had a higher energy expenditure than the rural women was because their weight was used to calculate the total energy expenditure. Thus though the rural women in this study work harder doing a lot of high intensity activity, their energy expenditure is less than the urban women probably because they weigh less.

Chapter seven: Discussion of results- medical issues during birth and activity levels

7.1 Medical problems during pregnancy

Discussion

Pregnancy is a diabetogenic event, which may develop into gestational diabetes in up to 1.4 to 12.3% of all pregnant women (148). In this study the percentage of women with gestational diabetes was 2.6% which is thus within normal international findings.

In a paper on the worldwide prevalence of anemia written for the World Health Organization, the global prevalence of anemia was estimated at 51% among pregnant women (149), compared with 35% among women in general. In New Zealand, in a cross-sectional national survey conducted in 1996/97, 41% of 20-49 years old non-pregnant women were at risk of low dietary iron intakes (150). The estimated percentage of 15-49 year old women with iron deficiency anemia ranged from 1.4 to 5.5%, and for iron deficiency without anemia from 0.7 to 12.6% depending on the age group and criteria used (150). A significantly lower prevalence of iron deficiency was seen among Pacific women. The investigators in this particular study found that the average dietary intakes and dietary iron density, plus intakes of dietary iron inhibitors (dietary fibre and calcium) and enhancers of iron absorption (vitamin C) were generally comparable across age and ethnic groups, except for calcium which was on average approximately 250-300 mg lower in Pacific women compared with the other two ethnic groups. In the present study the prevalence of low iron status in 38.1% of the study sample (31.6 % Europeans, 6.1% Maori and 0.4% Pacific People), is therefore low and compares favorably in the general population worldwide. One reason for this low prevalence could just be due to inaccurate recalling by the subjects as follow-up was only done on the phone and not by citing the actual reports. Therefore these results are not very reliable as they depend on the subjects ability to recall correctly. Interestingly in the present study too, a lower prevalence of iron deficiency was seen in the Pacific mothers, which could probably be due to their high red meat intake. The calcium intake in the Pacific women in this study was low. However, it is beyond the scope of this study to present the findings of the nutrition in pregnancy survey here. Most of the iron deficiency anemia in pregnancy has been attributed to iron deficiency. The higher prevalence for pregnant women is consistent with the estimated high iron needs during pregnancy. This is cause for concern given recent evidence that iron deficiency even without anemia has negative consequences on work capacity, mood and learning ability (149). Urgent measures are needed to improve the situation.

7.2 The impact of physical activity on the need for birth interventions

Discussion

In October 1999, the New Zealand Ministry of Health released an obstetric procedures report, which identified a relationship between lower rates of obstetric procedures, including induction of labor, epidural anaesthesia, episiotomy, operative vaginal delivery, caesarean section, and Maori and Pacific Island ethnicity (151). Adjusted analyses showed that rates of induction of labor, prelabor caesarean, and operative vaginal delivery were lower for Maori and Pacific women than for all other ethnicities grouped together (121). Overall caesarean delivery rates were not different for Maori or Pacific Island women. In the present study, no differences were seen by ethnicity in the need for birth interventions. These results were not adjusted for any confounding factors, which influence this relationship, although it is highly unlikely that after this adjustment, a relationship would have been observed. Also this could mean that birth interventions, were used by the women, only when they clinically needed it. In addition, since the follow-up was done by phone, there could have been incorrect reporting by some subjects. Moreover, very few Maori and Pacific women could be contacted for the follow-up questionnaire, so sufficient numbers were not obtained to carry out the analysis in some categories of birth intervention.

In this present study the need for birth interventions was highly significant for those who were sedentary. In a study by Clapp (106), it was seen that women who continued their regular exercise regimen throughout pregnancy experienced significantly less obstetric interventions. This included highly significant reductions in elective and indicated labor stimulation, episiotomy, and use of epidural anesthetic, as well as both vaginal and abdominal operative delivery. Furthermore women who discontinued exercise had a greater need for operative intervention and induction of labor. It is important to note here that these women were well-conditioned recreational athletes who had been regularly performing one or two specific types of exercise for several years. Thus extrapolation of these findings to other women may not be appropriate. In another study by Kardel et al (109), there was no difference in the need for birth intervention between the medium exercise and high exercise groups. Sedentary subjects were not studied in this particular study. The lack of adequate studies measuring outcome variables such as the need for birth interventions, pain relief, and physical activity in pregnancy makes comparison difficult.

From the results of the present study, it seems being active during pregnancy is beneficial for the pregnant mother during delivery, as less pain relief is required. However, the effect of other factors affecting this relationship was not investigated here and should be explored further. These findings could not be substantiated with that of other studies, as the author could not find any relevant reported study.

7.3 Effect of physical activity on length of labor

Discussion

The findings on the duration of labor and physical activity reported in this study are in agreement with some other studies (91,106). Although in this study sedentary activity was found to prolong labor, a study by Clapp (119) et al reported incidence of prolonged labor in the mothers who continued to exercise at the preconceptual level throughout pregnancy. However, the results were not significant. In another study by Magann et al (90), there was a trend to longer duration of the first stage of labor in nulliparous women in the higher energy expenditure group compared to those spending less. A meta-analysis of eighteen studies by Lokey et al (110), which measured the outcome variables for women who exercised while pregnant, showed no difference for exercising women and controls. These variables included maternal weight gain, gestational length, length of labor, infant birth weight and APGAR scores. Even when the various exercise prescriptions in relation to that recommended by the American College of Obstetricians and Gynecologists (ACOG) were looked at, no difference in outcomes was found between the groups that complied with the guidelines for mode and intensity and those that exceeded the guidelines. The overall results of this meta-analysis indicated that a pregnant woman can exercise up to three times a week for 43 minutes per session at a heart rate of 114 beats per minute without appearing to harm herself or her unborn child.

In the present study, the duration of labor was self-reported, and information on the duration of the stages of labor could not be obtained. However, in the light of the results of this study and that obtained from the meta-analysis, it is safe to conclude that moderate physical activity during pregnancy does not adversely affect the duration of labor.

7.4 Effect of physical activity on gestational age

Discussion

In the present study, women who were sedentary in the fourth month of pregnancy were found to give birth to infants with a shorter gestational age as compared to active women who were more likely to go full term. A study (104) on active and sedentary women found active women to have a longer gestational age compared to sedentary women. However, this result was not significant. A study by Koemeester (152), found that the daily duration of tasks with a high physical workload was significantly correlated with a shorter gestational age at delivery. This could be due to the fact that all subjects belonged to the same nursing profession as a result of which the chores they performed involved the same form of activities such as standing, squatting, stooping and sitting. The relationship between sedentary activity and gestational age could be due to other confounding factors such as parity, age of the mother, smoking etc not investigated here. However, in a study by Magann (90) et al the significance of this relationship remained even after multivariate modeling that controlled for age, parity and smoking.

7.5 Impact of physical activity on the health of the baby

Discussion

The anthropometric measures for 414 children have been presented in the tables 30, 31 and 32, although I followed-up on only 228 cases after the birth of the baby. This difference is because only a certain number of women had delivered when the telephonic interview was conducted. Moreover, out of those who had delivered only 228 could be contacted as some had a change of address, some had changed phone numbers and some were simply unavailable when contacted. Additionally by the time the data was analyzed, the birth details of babies born alive had been mailed to us by the midwives and so the number of babies whose data is reported here is higher than number followed up for the birth details questionnaire.

Birth weight is an important indicator of normal growth and development. In New Zealand, between 1980-93, the proportion of all infants weighing less than 2500g increased 10% from 54.1 per 1000 live births to 59.5 per 1000 live births (140,153). This increase for Europeans was 51.0 per 1000 live births in 1980 to 58.3 per 1000 live births in 1993. Both the Maori rate which is considerably higher than the European and the Pacific people rate which is considerably lower than the European have not changed much over the same period (140,153). In the present study, the percentage of low birth weight infants was much lower than the 5.9% seen in the earlier studies (140,153); and the Europeans had the highest and the Pacific people the lowest rate. One of the factors responsible for fetal growth is adequate prenatal weight gain (142). Recent studies indicate that 23 to 38% of women with low and normal body mass index have low prenatal weight gain as defined by the Institute of Medicine guidelines (142,146). One characteristic, working more than 40 hours per week when employed, was associated with low gain among white women (142). The European women in the present study gained the least weight by the seventh month of pregnancy compared to the other ethnic groups. This could probably have contributed to the low birth weight seen in European infants. However, their total weight gain by the end of pregnancy was not known. Moreover, in the present study, no significant difference in birth weight between the different ethnic groups and occupational groups were found. Taking larger number of Maori and Pacific people would have probably shown some differences.

In 1992, the leading causes of infant hospitalization were conditions originating in the perinatal period, diseases of the respiratory system (including acute respiratory condition), disorders relating to short gestation and birth defects (140). Maori rates for these causes were more than twice that for non-Maori. In this study, respiratory problems were the major reason for hospitalization. However, due to small numbers of Maori and Pacific mothers, it was not possible to carry out the analysis for ethnic differences in the need for hospitalization.

In the present study no relationship between Apgar scores and physical activity was found which is similar to the findings in other studies (105,106,107). A weak relationship seen between Apgar score at one minute and physical activity is in conflict with another study that found no relationship (104). This latter study found significant higher Apgar scores at five minutes in women who were sedentary (104). On the other hand, this result of the present study which was weakly significant is still consistent with the finding of other studies, which show a higher Apgar score in active mothers (108). Artal and colleagues (32) have suggested that as a result of maternal exercise fetal bradycardia may give rise to symptoms of hypoxia in some newborns. Also the Apgar scores, are known to be affected by the amount and type of medication administered during labor (104). Moreover, the variability in the clinical designation of

Apgar scores and the fact that any Apgar over 7.0 is considered good makes the weak significance seen in the present study of little clinical significance.

7.5.1 Factors affecting the birth weight of the baby

Discussion

In the meta-analysis by Lokey et al (110), no differences in birth weight or gestational age between exercising and non-exercising pregnant women were found. The findings in this study, of no significant effect of duration or intensity of physical activity on birth weight, is supported by this meta-analysis, but is in contrast to the findings of another New Zealand study by Watson which found that the more time the women spent lying down, the lower the birthweight of the baby (120).

In this study population, no relationship between birth weight and the occupational groups, ethnicity, location or income levels is seen. This could be because that in New Zealand being a welfare state, even those who are underprivileged do not go without primary care. The nutritional status of the mothers was assessed and has been presented elsewhere and it would be interesting to see if the nutritional status of the mothers had impacted on the lack of difference in birth weight (120). However, it is beyond the scope of this study to present these findings here.

Low pregravid BMI has been associated with an increase in the prevalence of late preterm delivery and spontaneous preterm labor among black and white women (142). In the present study, 3.86% of the infants had low birth weight, out of which 13.3% were born to underweight mothers, 26.67% to normal weight mothers, 40.0% to overweight mothers and 20% to obese mothers. Thus this could be due to other confounding variables.

Chapter Eight: Discussion of results-effect of physical activity on weight gain

8.1 Weight change during the fourth and seventh month of pregnancy and physical activity

Discussion

The positive energy balance necessary for gain in maternal and fetal tissue may be achieved by an increase in energy intake. Energy intake during pregnancy is a determinant of gestational weight gain (2,141). However, the relationship has been found to be weak (141). This relationship can be modified by a decrease or increase in physical activity, an increase in work efficiency, changes in basal metabolism, an increase in the efficiency with which energy is used to synthesize new tissue, or some combination of these factors. These differences in physiologic and behavioural responses to pregnancy may account for much variation in prenatal weight gain. In this study, the finding of a relationship between sedentary activity and weight gain and moderate high activity and weight loss is significant because accumulation of body fat is affected by energy balance. It is important to note however, that in this study, energy intake and expenditure have not been considered simultaneously which makes it difficult to determine their interaction for weight gain. In one Swedish study, energy intake was found to be strongly correlated with maternal fat accretion (154). Of course there are other factors, which are determinants of gestational weight such as number of pregnancies, socio-economic status, ethnicity, young age, unmarried status and low educational level.

Physical activity might affect fat accretion and fetal growth by two different mechanisms-energy restriction or redistribution of blood flow (156,157,158,159). It has been suggested that in developing countries excess physical activity may reduce the maternal weight gain and infant birthweight (156). Some studies in industrialized countries in the last trimester have reported that working in the last trimester was associated with a reduction in infant birthweight by 150-400g (158,159). Other studies did not find a relation between low birthweight and employment during pregnancy (157,160). Briend (161) found that a reduction in physical activity by bed rest, at least in the last trimester of pregnancy was associated with an increase in infant birthweight of about 200g.

8.2 Postpartum weight retention and physical activity during pregnancy

Discussion

In a New Zealand study by Watson (120), it was seen that the weight change from the fourth month of pregnancy to six months after birth of the baby was affected by variables measured during pregnancy. Thus it seems that the diet, activity and lifestyle patterns measured during pregnancy are maintained after birth. Furthermore, the study by Watson showed activity levels to be more important than diet in determining the weight loss after pregnancy (120).

Therefore, in the present study, the relationship between physical activity during pregnancy and weight retained postpartum was investigated. Although physical activity during the fourth and seventh months of pregnancy affected weight gain in the fourth and seventh months of pregnancy, no relationship was seen between physical activity during pregnancy and postpartum weight retention in the present study. This could mean that there could be other lifestyle factors during pregnancy such as nutrition, or lifestyle factors after delivery such as diet and activity, which could be affecting postpartum weight in this population.

Chapter Nine: Limitations of the study, conclusions and recommendations

9.1 Limitations of the study

The results of the current study should be interpreted in light of several methodologic issues.

Determination of the active and sedentary groups was based on self-report by participants of their exercise activities. This approach relied on individual interpretation of the nature, frequency, duration and intensity of each activity. Inherent in this methodology is the risk of subject bias in reporting. Inaccurate reporting may have resulted in measurement error.

Although the terms in the questionnaires were all pilot tested for understandability, it is likely that some of the terms may have been misinterpreted. In addition, participants were asked after delivery to report any discomforts that occurred late in the pregnancy, plus the type of labor, duration of labor, medical history, type of delivery, work history etc. This method relied on recall over as much as a one-year period. After a major life event, such as birth, the accuracy of the recall could be another source of error.

In retrospect, for the 228 who answered the telephone or mail administered questionnaire it would have been appropriate to analyze their data only at four month and seven months also so that it would have been a truly longitudinal study for the recording of the events at birth and maternal health recorded in the questionnaire.

The effect of exercise could easily be obscured by the wide normal variation in outcome caused by a multitude of other variables, including genetic and socioeconomic factors, nutrition and environmental factors. Therefore, a multiple regression analysis should have been carried out, as it would better clarify the effect of other confounding variables, which could affect the relationship seen here between a sedentary lifestyle and pregnancy outcome.

9.2 Conclusions

1. Most pregnant women spend on average almost twenty hours in sedentary activity both in the fourth and seventh month of pregnancy. Beneficiaries were overall more sedentary than the other pregnant women in the study. Urban women were more sedentary than the rural women.

2. Increasingly more women require birth interventions. Almost 43% of women in this study required some form of birth intervention. About 21% had caesarean births. Almost a quarter of the urban women in this study had a caesarean section as compared to 7.7% of rural women. About 20% needed an episiotomy. A strong relationship was observed for time spent in sedentary activity and episiotomy.

3. Almost 75% of the subjects in the study needed some form of pain relief. Eighty-five percent of the urban women needed some form of pain relief compared to only 15% of the rural women. Interestingly it was found that the more time spent in moderate high activity, the less was the need for pain relief.

4. The more the time spent in sedentary activity in the seventh month, the longer the labor and the more the time spent in sleeping in the seventh month the shorter the labor.

5. The birth weight of the baby was found to be significantly affected by the weight of the mother before pregnancy, weight at fourth month of pregnancy, weight at seventh month of pregnancy, height of the mother, triceps and costal skinfold thicknesses at fourth month, and biceps, triceps and costal skinfold thicknesses at seventh month.

6. A strong relationship between gestational age and sedentary activity was found. The more sedentary the mother, the shorter was the gestational age and the more active the mother the more likely she was to go full term.

7. Every minute spent in sleeping and sedentary activity during the fourth month led to a weight gain of 0.0052 kilograms of body weight between the fourth and seventh month of pregnancy ($p<0.05$). In the fourth month, every minute spent in moderate high activity and moderate low to moderate high categories combined led to weight loss of 0.00718 and 0.00488 kilograms respectively ($p<0.05$). Thus the net effect between these two groups was a weight loss of 0.0023 kilograms with every minute spent in activities of moderate low to moderate high category. However, the overall effect of physical activity in the fourth month was a net weight gain of 0.0029 kilograms.

8. Time spent in sedentary activity in the seventh month showed a strong relationship with weight gain during the fourth to seventh months of pregnancy. The women were found to gain 0.00444 kilograms with every extra minute spent in sedentary activity. Weight loss of 0.00637 kilograms was also seen with every minute spent in moderate high activity. Even when the moderate low to moderate high categories in the seventh month were combined, weight loss of 0.00464 kilograms was observed. Thus with every

minute spent in moderate low to moderate high activity categories, the net weight loss was 0.00173 kilograms.

9. Postpartum weight retention was not affected by time spent in physical activity in pregnancy. Postpartum weight retention did not differ by occupational groups, income or educational status but it did differ by ethnicity. The Pacific people were found to retain the most weight.

9.3 Recommendations

The results of this study clearly imply the importance of a good active lifestyle to ensure a smooth course of pregnancy and pregnancy outcome. The relationship seen between the need for birth interventions and sedentary activity needs to be explored further. The type of pain relief and the number of pain relief options taken during labor plus the birth interventions used, could have been incorrectly recalled by the subjects. It would have been better to verify this information from their medical records.

Furthermore, adequate number of subjects in each ethnic group category is needed in order to carry out the analysis appropriately. In some of the analysis, such as cross tabulations of ethnic groups with other variables such as birth interventions, type of pain relief etc, the analysis could not be carried out successfully due to lack of enough numbers. In future studies, it is important to ensure bigger samples from the Maori and Pacific groups.

To isolate the effects of maternal physical activity on fetal and maternal outcome, large well-controlled, prospective epidemiological studies are necessary. The importance of doing so can only be understood if we see both physical activity during pregnancy and pregnancy per se as potential variables that may alter long-term cardiovascular function and risk either directly or through their effects on an individual's physical activity profile.

It is recommended that:

1. Pregnant women should be dynamically encouraged to become more active as the more the time spent in sedentary activity

    - The greater the need for some birth interventions eg. episiotomy
    - The greater the need for pain relief during labor
    - The longer the duration of labor
    - The shorter the gestational age of the baby, with all the attendant risks that this entails

    Midwives and doctors should prescribe at least 60 minutes of moderate physical activity per day. Pregnant women should be advised to avoid activities involving excessive standing and sitting. Workplace physical activity programs should be put in place so that all benefit and especially those pregnant women involved in occupations requiring a lot of sedentary activity.

2. Postpartum weight retention was highest in Pacific women. As high obesity levels present serious health risks in this group, factors that contribute to this high weight retention need to be identified, and actively remedied.

3. Though no significant difference in physical activity by ethnicity was found in this study, it is still important to attempt to get the high risk ethnic groups to get more active. Social marketing campaigns aimed at increasing physical activity and healthy lifestyles often do not take into account the self-care resources, the socioeconomic realities and cultural

health values of the high risk ethnic communities in New Zealand. The assumption underpinning social marketing campaigns is that people have the resources to act but lack awareness or motivation. Having come from a different cultural background and my work in health promotion in the community over the years has taught me that health promotion behaviours and attitudes regarding body weight, diet, and physical activity are complex and deeply linked to cultural values, socioeconomic capacity, and health belief systems. Effective behaviour changing interventions would need to involve more than public service announcement campaigns. There is a need for more culture and language specific programs for these ethnic groups and should be delivered by health professionals from these ethnocultural background.

4. As more and more women are using birth interventions and especially caesarean sections, it is important to educate them to allow them to make well informed decisions in order to avoid unnecessary expenditure and burden to the healthcare system.

References

1. Anderssen, N., Jacobs, DR Jr. & Sidney S.(1994). Longitudinal changes in adiposity associated with pregnancy: The CARDIA study. Journal of the American Medical Association 271(22), 1747-1751.

2. Ohlin, A., & Rossner, S. (1994). Trends in eating patterns, physical activity and socio-demographic factors in relation to postpartum body weight development. British Journal of Nutrition 71, 457-470.

3. Gross, T. Sokol, R.S., & King, K. (1980). Obesity in pregnancy: Risks and outcome. Obstetrics & Gynecology 56, 446-450.

4. Johnson, J., Longmate, J.A., & Frentzen, B. (1992). Excessive maternal weight and pregnancy outcome. American Journal of Obstetrics & Gynecology 167, 353-72.

5. Solomon, C.G., Willett, W.C., Carey, V.J., Rich-Edwards, J., Hunter, D.J., Colditz, G.A., Stampfer, M.J., Speizer, F.E., Spiegelman, D., & Manson, J.E. (1997). A prospective study of pregravid determinants of gestational diabetes mellitus. Journal of the American Medical Association 278 (13), 1078-1083.

6. Crane, S.S., Wojtowycz, M.A., Dye, T.D., Aubry, R.H., & Artal, R. (1997). Association between pre-pregnancy obesity and the risk of cesarean delivery. Obstetrics & Gynecology 89, 213-216.

7. Witter, F.R., Caulfield, L.E., & Stoltzfus, R.J. (1995). Influence of maternal anthropometric status and birth weight on the risk of cesarean delivery. Obstetrics & Gynecology 1995, 947-951.

8. Edwards, L.E., Dicks, W.F., Alton, L.R., & Hadanson, E.Y. (1978). Pregnancy in the massively obese: Course, outcome and obesity prognosis of the infant. American Journal of Obstetrics & Gynecology 131, 479-483.

9. Perlow, J.H., Morgan, M.A., Montgomery, D.M., Towers, C.V., & Porto, M. (1992). Perinatal outcome in pregnancy complicated by massive obesity. American Journal of Obstetrics Gynecology 167, 958-962.

10. Perlow, J.H., & Morgan, M.A. (1994). Massive maternal obesity and perioperative cesarean morbidity. American Journal of Obstetrics & Gynecology 170, 560-565.

11. Hetimann, B.L., Kaprio, J., Harris, J.R., Rissamen, A., Korkeila, M., & Koskenvuo, M. (1997). Are genetic determinants of weight gain modified by leisure-time physical activity? A prospective study of Finnish twins. American Journal of Clinical Nutrition 66, 672-678.

12.Berkowitz, G.S. (1981). An epidemiological study of preterm delivery. American Journal of Epidemiology 113, 81-92.

13. Carmichael, S.L., & Abrams, B. (1997). A critical review of the relationship between gestational weight gain and preterm delivery. Obstetrics & Gynecology 89, 865-73.

14. Siega-Riz, A.M., Adair, L.S., & Hobel, C.J. (1994). Institute of Medicine maternal weight gain recommendations and pregnancy outcome in a predominantly Hispanic population. Obstetrics & Gynecology 84, 565-573.

15. Clark, P.M., Atton, C., Law, C.M., Shiell, A., Godfrey, K., & Barker, D.J.P. (1998). Weight gain in pregnancy, triceps skinfold thickness, and blood pressure in offspring. Obstetrics & Gynecology 91, 103-107.

16. Lederman, S.A., Paxton, A., Heymsfield, S.B., Wang, J., Thornton, J., & Pierson, R.N. (1997). Body fat changes and water changes during pregnancy in women with different body weight and weight gain. Obstetrics & Gynecology 90, 483-488.

17. Bell, R., & O'Neill, M. (1994). Exercise and pregnancy: A review. Birth 21(2), 85-95.

18. Jones, R.L., Botti, J.J., Anderson, W.M., & Bennett, N.L. (1985). Thermoregulation during aerobic exercise in pregnancy. Obstetrics & Gynecology 65, 340-345.

19. Clapp, J.F., Rokey, R., Treadway, J.L., Carpenter, M.W., Artal, R.M., & Warrnes, C. (1992). Exercise in pregnancy. Medicine Science in Sports Excercise 24(6), S294-S300.

20. Clapp, J.F., Little, K.D., Appleby-Wineberg, S.K., & Widness, J.A. (1995). Fetus - placenta - newborn: The effect of regular maternal exercise on eryhtropoietin in cord blood and amniotic fluid. American Journal of Obstetrics & Gynecology 172(5), 1445-1451.

21. Clapp, J.F. (1994). A clinical approach to exercise in pregnancy. Clinical Sports Medicine 13, 443-458.

22. Lotgering, F.K., Gilbert, R.D., & Longo, L.D. (1985). Maternal and fetal responses to exercise during pregnancy. Physiological Reviews 65, 1-36.

23. Poppitt,S.D., Prentice, A.M., Goldberg, G.R., Roger, S., & Whitehead, R.G.(1994). Energy-sparing strategies to protect human fetal growth. American Journal of Obstetrics and Gynecology 171, 118-125.

24. Knuttgen, H.G. & Emerson, K. (1974). Physiological response to pregnancy at rest and during exercise. Journal of Applied Physiology 36, 549-553.

25. Felig, P. (1977). Body fuel metabolism and diabetes mellitus in pregnancy. Medical Clinics of North America 61, 43-66.

26. Guzman, C.A. & Caplan, R. (1970). Cardiorespiratory response to exercise during pregnancy. American Journal of Obstetrics and Gynecology 108(4), 600-605.

27. Cohn, H.E., Jackson, B.T., Piasecki, G.J., Cohen, W,R., & Novy, M.J. (1985). Fetal cardiovascular responses to asphyxia induced by decreased uterine perfusion. Journal of Developmental Physiology 7, 289-297.

28. Simpson, E.R. & MacDonald P.C. (1981). Endocrine physiology of the placenta. Annual Reviews of Physiology 43, 163-188.

29. Soultanakis, H.N., Artal, R. & Wiswell, R.A. (1996). Prolonged exercise in pregnancy: Glucose homeostasis, ventilatory and cardiovascular responses. Seminars in Perinatology 20(4), 315-327.

30. Jarski, R.W., & Trippett, D.L. (1990). The risks and benefits of exercise during pregnancy. Journal of Family Practice 30,185-189.

31. Jarrett, J.C., & Spellacy, W.N. (1983). Jogging during pregnancy: An improved outcome. Obstetrics & Gynecology 61, 705-709.

32. Artal, R., Rutherford, S., Romem, Y., Kammula, R.K., Dorey, F.J., & Wiswell, R.A. (1986). Fetal heart rate responses to maternal exercise. American Journal of Obstetrics & Gynecology 155, 729-33.

33. Lee, C., Di Loreto, P.C. & O'Lane, J.M. (1975). A study of fetal heart rate acceleration patterns. Obstetrics & Gynecology 45, 42-44.

34. Skillman, C.A., Plessinger, M.A., Woods, J.R., & Clark. K.E. (1985). Effect of graded reductions in uteroplacental blood flow on the fetal lamb. American Journal of Physiology 249, H1098-H1105.

35. Itskovitz, J., Lagamma, E.F., & Rudolph, A.M. (1983). The effect of reducing umbilical blood flow on fetal oxygenation. American Journal of Obstetrics & Gynecology 145, 813-818.

36. Artal, R., Romem, Y., Paul, R.H., & Wiswell, R. (1984). Fetal bradycardia induced by maternal exercise. The Lancet 4, 258-260.

37. Carpenter, M.W., Sady, S.P., Hoegsberg, B., Sady, M.A., Haydon, B., & Coustan, D.R. (1988). Fetal heart rate response to maternal exertion. Journal of the American Medical Association 259, 306-309.

38. Clapp, J.F., Little, K.D., & Capeless, E.L. (1993). Fetal heart rate response to sustained recreational exercise. American Journal of Obstetrics & Gynecology 168(1), 198-206.

39. Zanjani, E.D., Poster, J., & Burlington, H. (1977). Liver as the primary site of eryhtropoietin formation in the fetus. Journal of Laboratory Clinical Medicine 89, 640-644.

40. Finne, P.H., & Halvorsen, S. (1972). Regulation of erythropoisis in the fetus and newborn. Archives of the Diseased Child 47, 683-688.

41. Collings, C., & Curet, L.B. (1985). Fetal heart rate response to maternal exercise. American Journal of Obstetrics & Gynecology 151, 498-501.

42. Watson, K.V.L., Hackney, A.C., Gall, M.M., & McMurray, R.G. (1991). Fetal responses to maximal swimming and cycling exercise during pregnancy. Obstetrics & Gynecology 77, 382-386.

43. Cooper, K.A., Hunyor, S.N., Boyce, E.S., O'Neill, M.E. & Frewin, D.B. (1987). Fetal heart rate and maternal cardiovascular and catecholamine responses to dynamic exercise. Australian & New Zealand Journal of Obstetrics & Gynecology 27, 220-223.

44. Collings, C.A., Curet, L.B. & Mullin, J.P. (1983). Fetal heart rate response to maternal exercise. American Journal of Obstetrics & Gynecology 145, 702-707.

45. Clapp, J.F. & Capeless, E. (1997). Cardiovascular function before, during, and after the first pregnancies. American Journal of Cardiology 80, 149-1473.

46. Hauth, J.C., Gilstrap, L.C., & Widmer, K. (1982). Fetal heart rate reactivity before and after maternal jogging during the third trimester. American Journal of Obstetrics & Gynecology 142, 545-547.

47. Steegers, E.A.P., Buunk, G., Binhorst, R.A., Jongsma, H.W., Wijn, P.F.F., & Hein, P.R. (1988). The influence of maternal exercise on the utetroplacental vascular bed resistance and the fetal heart rate during normal pregnancy. European Journal of Obstetrics Gynecology & Reproductive Biology 27, 21-26.

48. Kilham, L., & Ferm, V.H. (1976). Encephaly in fetal hamsters following exposure to hyperthermia. Teratology 14, 323-326.

49. Edwards, M.J. (1969). Congenital defects in the guinea pigs: Fetal resorptions, abortions, and malformations following induced hyperthermia during early gestation. Teratology 2, 313-328.

50. Lotgering, F.K., Gilbert, R.D., & Longo, L.D. (1983). Exercise responses in pregnant sheep: Blood gases, temperatures, and fetal cardiovascular system. Journal of Applied Physiology 55, 842-850.

51. Clapp, J.F. Wesley, M., & Sleamaker, R.H. (1987). Thermoregulatory and metabolic responses prior to and during pregnancy. Medicine & Science in Sports & Exercise 19(2), 124-130.

52. Clapp, J.F. The changing thermal response to endurance exercise during pregnancy (1991). American Journal of Obstetrics & Gynecology 165, 1684-1689.

53. Moore, L.G., Hershey, D.W., Jahnigen, D. & Bowes, W. (1982). The incidence of pregnancy-induced hypertension is increased among Colorado residents at high altitude. American Journal of Obstetrics and Gynecology 144, 423-429.

54. Hutch, R. (1996). Physical activity at altitude in pregnancy. Seminars in Perinatology 20(4), 303-314.

55. Moran, J.J.M. (1988). Stress fractures in pregnancy. American Journal of Obstetrics & Gynecology 158, 1274-1277.

56. Williams, J.K., McClain, L., Rosemurgy, A.S., & Colorado, N.M. (1990). Evaluation of blunt abdominal trauma in the third trimester of pregnancy: Maternal and fetal considerations. Obstetrics & Gynecology 75, 33-37.

57. Rose, P.G., Strohm, P.L., & Zuspan, F.P. (1985). Fetoplacental hemorrhage following trauma. American Journal of Obstetrics & Gynecology 153, 844-847.

58. Ueland, K., Novy, M.J., Pererson, E.N. & Metcalfe, J. (1973). Cardiorespiratory responses to pregnancy and exercise in normal women and patients with heart disease. American Journal of Obstetrics and Gynecology 115, 4 -11.

59. Erkkola, R.U., Pirhonen, J.P., & Kivijarvi, A.K. (1992). Flow velocity waveforms in uterine arteries during submaximal bicycle exercise in normal pregnancy. Obstetrics & Gynecology 79, 611-615.

60. Pinto, M.L., & Shetty, P.S. (1995). Influence of exercise induced maternal stress on fetal outcome in Wistar rats:Inter-generational effects. British Journal of Nutrition 73, 645-653.

61. Easterling, T.R., Benedetti, T.J., Schmucker, B.C. & Millard, S.P.(1990). Maternal hemodynamics in normal and preeclamptic pregnancies: A longitudinal study. Obstetric & Gynecology 76, 1061-1069.

62. Zhang, J., Zeisler, J., Hatch, M.C. & Berkowitz, G. (1997). Epidemiology of Pregnancy-Induced Hypertension. Epidemiologic Reviews 19(2), 218-222.

63. Spinillo, A., Capuzzo,E., Colonna, L., Piazzi, G., Nicola, S., & Baltaro,F.(1995). The effect of work activity in pregnancy on the risk of severe eclampsia. Australian & New Zealand Journal of Obstetrics & Gynecology 35(4), 380-385.

64. Marcoux, S., Brisson, J., & Fabia, J. (1989). The effect of leisure time physical activity on the risk of pre-eclampsia and gestational hypertension. Journal of Epidemiology & Community Health 43, 147-152.

65.Sibai, B.M. (1990). Eclampsia VI. Maternal-perinatal outcome in 254 consecutivecases. American Journal of Obstetrics & Gynecology 163, 1049-1055.

66. Stone, J.L., Lockwood, C.J., Berkowitz, G.S., Alvarez, M., Lapinski, R., & Berkowitz, R.L. (1994). Risk factors for severe preeclampsia. Obstetrics & Gynecology 83, 357-361.

67. Lindsay, C.A., Huston, L., Amini, S.B., & Catalano, P.M. (1997). Longitudinal changes in the relationship between body mass index and percent body fat in pregnancy. Obstetrics & Gynecology 89, 377-82.

68. Bung, P., Bung, C., Artal, R., Khodiguian, N., Fallenstein, F., & Satling, L. (1993). Therapeutic exercise for insulin-requiring gestational diabetics: effects on the fetus - results of a randomised prospective longitudinal study. Journal of Perinatal Medicine 21, 125-137.

69. Casey, B.M., Lucas, M.J., Mintire, D.D., & Levene, K.J. (1997). Pregnancy outcomes in women with gestational diabetes compared

with the general obstetric population. Obstetrics & Gynecology 90, 869-873.

70. Vohr, B.R. & McGarvey, S.T. (1997). Growth patterns of large-for-gestational age and appropriate-for-gesttaional-age infants of gestational diabetic mothers and control mothers at age 1 year. Diabetes Care 20(7), 1066-1072.

71. Silverman, E.B., Rizzo, T., Green. O.C., Cho, N.H., Winter, R.J., Ogata, E.S., Richards, G.E. & Metzger, B.E. (1991). Long-term prospective evaluation of offspring of diabetic mothers. Diabetes 40, 121-125.

72. Petit, D.J., Knowler, W.C., Bennett, P.H., Aleck, K. & Baird, H.R. (1987). Obesity in offsprings of Pima Indian women despite normal birth weight. Diabetes Care 10, 76-80.

73. Fuhrmann, K., Reiher, H., Semmler, K., Friedricke, F., Fischer, M. & Glockner, E.(1983). Prevention of congenital malformations in infants of insulin-dependent diabetic mothers. Diabetes Care 6, 219-223.

74. Pederson, O., Beck-Nielsen, M. & Heding, L. (1980). Increased insulin receptors after exercise in patients with insulin-dependent diabetes mellitus. New England Journal of Medicine 302, 886-892.

75. Jovanovic-Peterson, L., Durak, E.P., & Peterson, C.M. (1989). Randomized trial of diet versus diet plus cardiovascular conditioning on glucose levels in gestational diabetes. American Journal of Obstetrics & Gynecology 161, 415-419.

76. Bung, P., Artal, R., Khodiguian, N. & Kjos, S. (1991). Exercise in gestational diabetes. An optional therapeutic approach? Diabetes 40(S2), 182-185.

77. Avery, M.D., Leon, A.S., & Kopher, R.A. (1997). Effects of a home-based exercise program for women with gestational diabetes. Obstetrics & Gynecology 89(1), 10-15.

78. Dye, T.D., Knox, K.L., Artal, R., Aubry, R.H., & Wojtowycz, M.A. (1997). Physical activity, obesity, and diabetes in pregnancy. American Journal of Epidemiology 146, 961-965.

79. Solomon, C.G., Willett, W.C., Carey, V.J., Rich-Edwards, J., Hunter, D.J., Colditz, G.A., Stampfer, M.J., Speizer, F.E., Spiegelman, D.S. & Manson, J.E. (1996). Variability in diagnostic evaluation and screening for gestational diabetes. Diabetes Care 19, 12-16.

80. Gabbe, S.G., & Turner, L.P. (1997). Reproductive hazards of the American lifestyle: Work during pregnancy. American Journal of Obstetrics & Gynecology 176(4), 826-832.

81. Briend A. (1979). Fetal malnutrition – the price of upright posture? British Medical Journal 2, 317-319.

82. Schoeller, D.A., Shay, K., & Kushner, R.F. (1997). How much physical activity is needed to minimize weight gain in previously obese women? American Journal of Clinical Nutrition 66, 551-556.

83. Henriksen, T.B., Savtz, D.A., Hedegaard, M., & Secher, N.J. (1994). Employment during pregnancy in relation to risk factors and pregnancy outcome. British Journal of Obstetrics & Gynecology 101, 858-865.

84. Hickey, C.A., Cliver, S.P., Goldenberg, R.L., McNeal, S.F., & Hoffman, H.J. (1997). Low prenatal weight gain among low-income women: What are the risk factors? Birth 24, 102-108.

85. Mamelle, N., Laumon, B., & Lazar, P. (1984). Prematurity and occupational activity during pregnancy. American Journal of Epidemiology 119, 309-22.

86. Florack, E.I.M., Pellegrino, A.E.M.C., Zielhuis, G.A., & Rolland, R. (1995). Influence of occupational activity on pregnancy duration and birthweight. Scandinavian Journal of Work & Environmental Health 21, 199-207.

87. Meis, P.J., Michielutte, R., Peters, T.J., Wells, H.B., Evan, S.R., Coles, E.C., & Johns, K.A. (1995). Obstetrics: Factors associated with preterm birth in Cardiff, Wales. I. Univariable and multivariable analysis. American Journal of Obstetrics & Gynecology 173(2), 590-596.

88. Fenster, L., Hubbard, A.E., Windham, G.C., Waller, K.O., & Swan, S.H. (1997). A prospective study of work-related physical exertion and spontaneous abortion. Epidemiology 8, 66-74.

89. Teitelman, A.M., Welch, L.S., Hellenbrand, K.G., & Bracken, M.B. (1990). Effect of maternal work activity on preterm birth and low birth weight. American Journal of Epidemiology 131, 104-113.

90. Magann, E.F., Evans, S.F., & Newnham, J.P. (1996). Employment, exertion, and pregnancy outcome: Assessment by kilocalories expended each day. American Journal of Obstetrics & Gynecology 175(1), 182-187.

91. Clapp, J.F. (1989). The effects of maternal exercise on early pregnancy outcome. American Journal of Obstetrics & Gynecology 161, 1453-1457.

92. Wolfe, L.A., Brenner, I.K.M., & Mottola, M. F. (1994). Maternal exercise, fetal well-being and pregnancy outcome. Exercise & Science Sports Reviews 22, 145-194.

93. Sternfield, B. (1997). Physical activity and pregnancy outcome. Sports Medicine 23(1), 33-47.

94. Berkowitz, G.S. & Papiernik, E. (1995). Working conditions, maternity legislation, and preterm birth. Seminars in Perinatology 19(4), 272-278.

95. Berkowitz, G.S., Kelsey, J.L., Holford, T.R. & Berkowitz, R.L. (1983). Physical activity and the risk of spontaneous delivery. Journal of Reproductive Medicine 28, 581-588.

96. Naeye, R.L., & Peters, E.C. (1982). Working during pregnancy: Effects on the fetus. Pediatrics 69(6), 724-727.

97. Katz, L.V. (1996). Water exercise in pregnancy. Seminars in Perinatology 20(4), 285-291.

98. Camporesi, E.M. (1996). Diving and Pregnancy. Seminars in Perinatology 20(4), 292-302.

99. Terada, M. (1974). Effect of physical activity before pregnancy on fetuses forcibly exercised during pregnancy. Teratology 10, 141-144.

100. Spinillo, A., Capuzzo, E., Baltaro, F., Piazzi, G., Nicola, S., & Iasci, A. (1996). The effect of work activity in pregnancy on the risk of fetal growth retardation. Acta Obstetrica Gynecologica Scandinavia 75, 531-536.

101. Henriksen, T.B., Hedegaard, M., Secher, N.J., & Wilcox, A. J. (1995). Standing at work and preterm delivery. British Journal of Obstetrics & Gynecology 102, 198-206.

102. Ahlborg, G. (1995). Physical work- load and pregnancy outcome. Journal of Occupational & Environmental Medicine 37(8), 941-944.

103. Erdeyli, G.J. (1962). Gynecological survey of female athletes. Journal of Sports Medicine and Physical Fitness 2, 174-179.

104. Horns, P.N., Ratcliffe, L.P., Leggett, J.C., & Swanson, S.M. (1994). Pregnancy outcomes among active and sedentary primiparous

women. Journal of Obstetrics Gynaecology & Neonatology 25, 49-54.

105.Kulpa, F.J., White, B.M. & Visschr, R. (1987). Aerobic exercise in pregnancy. American Journal of Obstetrics and Gynecology 156, 1395-1403.

106. Clapp, J.F. (1990). The course of labor after endurance exercise during pregnancy. American Journal of Obstetrics & Gynecology 163, 1799-1805.

107. Pomerance, J.J., Gluck, L., & Lynch, V.A. (1974). Physical fitness in pregnancy: its effect on pregnancy outcome. American Journal of Obstetrics and Gynecology 119, 867-876.

108. Hall, D.C., & Kaufman, D.A. (1987). Effects of aerobic and strength conditioning on pregnancy outcomes. American Journal of Obstetrics and Gynecology 157, 1199-1203.

109. Kardel, K. R. & Kase, T. (1998). Training in pregnant women: Effects on fetal development and birth. American Journal of Obstetrics and Gynecology 178(2), 280-286.

110. Lokey, E.A., Tran, Z.V., Wells, C.V., Myers, B.C. & Tran, A.C. (1991). Effect of physical exercise on pregnancy outcomes: a meta-analytic review. Medicine & Science in Sports & Exercise 23, 1234-1239.

111. Wong, S.C. & McKenzie,D.C.(1987). Cardiorespiratory fitness during pregnancy and its effect on outcome. International Journal of Sports Medicine 8, 79-83.

112. Wallace, A.M. & Engstrom, J.L.(1987). The effects of aerobic exercise on the pregnant women, fetus and pregnancy outcome. A review. Journal of Nurse-Wifery 32, 277-290.

113. Zeanah, M. & Schlosser, S.P. (1993). Adherence to ACOG guidelines on exercise during pregnancy: Effect on pregnancy outcome. Journal of Obstetric, Gynecologic, and Neonatal Nursing 22, 329-335.

114. Dale, E., Mullinax, K.M. & Bryan, D.H. (1982). Exercise during pregnancy: effects on the fetus. Canadian Journal of Applied Sports Science 7, 98-103.

115. Dewey, K.G. & McCrory, M.A. (1994). Effects of dieting and physical activity on pregnancy and lactation. American Journal of Clinical Nutrition 59(suppl), 446s-453s.

116. Clapp, J.F., & Capeless, E. (1990). Neonatal morphometrics after endurance exercise during pregnancy. American Journal of Obstetrics & Gynecology 163, 1805-1811.

117. Artal, R., Masaki, D.I., Khodiguian, N., Romem, Y., Rutherford, S.E., & Wiswell, R.A. (1989). Exercise prescription in pregnancy: Weight-bearing versus non-weight-bearing exercise. American Journal of Obstetrics & Gynecology 161, 1464-1469.

118. Clapp, J.F. (1996). Pregnancy outcome: Physical activity inside versus outside the work place. Seminars in Perinatology 20(1), 70-76.

119. Clapp, J.F. & Dickstein, S. (1984). Endurance exercise and pregnancy outcome. Medicine & Science in Sports & Exercise 6(6), 556-562.

120. Watson P., McDonald B. Nutrition During Pregnancy. Report to The Ministry of Health 1999, 1-139.

121. Watson, P.E.(1996). Maternal Nutrition and Infant Outcome, Report to the Ministry of Health, 1-104.

122. Sadler, L., McCowan, L. & Stone, P. (2002). Associations between ethnicity and obstetric intervention in New Zealand. New Zealand Medical Journal 115, 36-39.

123. Sady, S.P. & Carpenter, M.W. (1989). Aerobic exercise during pregnancy: Special Considerations. Sports Medicine 7, 357-375.

124. Witter, F.R., Caulfield, L.E. & Stoltzfus, R.J. (1995). Influence of maternal anthropometric status and birth weight on the risk of cesarean delivery. Obstetrics and Gynecology 85, 947-951.

125. Clapp, J.F., & Little, K.D. (1995). The interaction between regular exercise and selected aspects of women's health. American Journal of Obstetrics & Gynecology 173(1), 2-9.

126. Hatch, E.A., Shu, X.O. & McLean, D.E.(1991). Maternal exercise during pregnancy, physical fitness, and fetal growth. American Journal of Epidemiology 137, 1105-1114.

127. Rabkin, C.S., Anderson, H.R., Bland, J.M., Brooke, O.G., Chamberlain, G., & Peacock, J.L. (1990). Maternal activity and birth weight: A prospective, population-based study. American Journal of Epidemiology 131(3), 522-531.

128. Fedrick J, & Adelstein P (1978). Factors associated with low birth weight of infants delivered at term. British Journal of Obstetrics & Gynaecology 85, 1-7.

129.Brooke O.G., Anderson H.R., & Bland J.M. (1989). The effects on birth weight of smoking, alcohol, caffeine, socio-economic factors, and psychosocial stress. British Medical Journal 298, 796-801.

130.Wolfe, L.A., Hall, P., Webb, K.A., Goodman, L., Monga, M. & McGrath, M.J. (1989). Prescription of aerobic exercise during pregnancy. Sports Medicine 8(5), 273-301.

131.Clapp, J.F., Little, K.D. & Capeless, E.F. (1993). Fetal heart rate response to various intensities of recreational exercise during mid and late pregnancy. American Journal of Obstetrics & Gynecology 168, 198-206.

132.Clapp, J.F. III, Little, K.D., Appleby-Wineberg, S.K. & Widness, J.A. (1995). The effect of regular maternal exercise on erythropoietin in cord blood and amniotic fluid. American Journal of Obstetrics & Gynecology 172, 1445-1451.

133.Wolfe, L.A., Brenner, I.K.M. & Mottola, M.F. (1994). Maternal exercise, fetal well-being and pregnancy outcome. Exercise and Sport Science Reviews 22, 145-194.

133. Passmore, R. &Durnin, J.G.V.A. (1955). Human energy expenditure. Physiological Reviews 35, 801-840.

134.Blair, S.N., Haskell, W.L., Ho, P., Paffenbarger, R.S., Vranizan, K.M., Farquhar, J.W. & Wood, P.D. (1985). Assessment of habitual physical activity by a seven-day recall in a community survey and controlled experiments. American Journal of Epidemiology 122, 794-804.

135.Bratteby, L.E., Sandhagen, B., Fan, Hu & Samuelson, G. (1997). A 7-day activity diary for assessment of daily energy expenditure validated by the doubly labeled water method in adolescents. European Journal of Clinical Nutrition 51, 585-591.

136. Spurr, G.B., Prentice, A.M., Murgatroyd, P.R., Goldberg, G.R., Reina, J.C. & Christman, N.T. (1988). Energy expenditure from minute-by-minute heart-rate recording: a comparison with indirect calorimetry. American Journal of Clinical Nutrition 48, 552-559.

137. Reiff, G.G., Montoye, H.J., Remington, R.D., Napier, J.A., Metzner, H.L. & Epstein, F.H. (1967). Assessment of physical activity by questionnaire and interview. Journal of Sports Medicine and Physical Fitness 7, 135-142.

138.Ainsworth, B.E., Haskell, W.J., Leon, A.S., Jacobs, D.J., Montoye, H.J., Sallis, J.F., & Paffenbarger, R.S. (1993). Compendium of physical activities: classification of energy costs of human physical activities. Medicine Science in Sports & Exercise 25(1), 71-80.

139.Gibson, R.S., Principles of Nutritional Assessment, Oxford University Press, 1990, Oxford.

140.Lifecycle Health Status in Our Health Our Future: The State of Public Health in New Zealand, 1994. Chapter 3, pp.133.

141. Institute of Medicine. Subcommittee on Nutritional Status, and weight gain during pregnancy. Nutrition during pregnancy. Washington, DC: National Academy of Sciences, National Academy Press, 1990; pp. 5-8.

142.Hickey, C.A., Cliver, S.P., McNeal, S.F. & Goldenberg, R.L. (1997). Low pregravid BMI as a rsik factor for preterm birth:Variation by ethnic group. Obstetrics & Gynecology 89, 206-212.

143.Physical Activity in "Taking the pulse." The 1996/97 NZ Health Survey. Ministry of Health. Published in April 1999 by Ministry of Health, Wellington, New Zealand. Chapter 3, 41-50.

144.Clissold, T.S., Hopkins, W.G. & Seddon, R.J. (1991). Lifestyle behaviours during pregnancy. New Zealand Medical Journal 104, 111-113.

145.Rose, N.C., Haddow, J.E., Palomaki, G.E. & Knight, G.J. (1991). Self-rated physical activity level during the second trimester and pregnancy outcome. Obstetrics & Gynecology 78, 1078-1080.

146.Bianco, A.T., Smilen, S.W., Davis, Y., Lopez, S., Lapinski,R., & Lockwood, C.J.(1998). Pregnancy outcome and weight gain recommendations for the morbidly obese woman. Obstetrics & Gynecology 91, 97-102.

147.Keppel, K.G. & Taffel, S.M. (1993). Pregnancy-related weight gain and retention: Implications of the 1990 Institute of Medicine guidelines. American Journal of Public Health 83, 1100-1103.

148.Bung, P. & Artal, R. (1996). Gestational diabetes and exercise: A survey. Seminars in Perinatology 20(4), 328-333.

149.DeMaeyer, D. & Adiels-Tegman, M. (1985). The prevalence of anemia in the world. World Health Statistics Quarterly 38, 302-316.

150.Ferguson, E.L., Morison, I.M., Faed, J.L., Parnell, W.R., McKenzie, J., Wilson, N. C. & Russell, D.G. (2001). Dietary iron intakes and biochemical iron status of 15-49 year old women in New Zealand: is there a cause for concern? New Zealand Medical Journal 114, 134-138.

151.New Zealand Ministry of Health Obstetric procedures 1988/89-1997/98, 1999. http://www.moh.govt.nz

152.Koemeester, A.P., Broersen, J.P.J., & Treffers, P.E. (1995). Physical work load and gestational age at delivery. Occupational & Environmental Medicine 52, 313-315.

153.Borman, B., Boer G. & Fraser, J. (1990). Risk factors for low birthweight in New Zealand, 1981-83. New Zealand Medical Journal 103, 92-94.

154.Langhoff-Roos, J., Lindmark, G., Kylberg, E., & Gebre-Medhin, M. (1987). Energy intake and physical activity during pregnancy in relation to maternal fat accretion and infant birthweight. British Journal of Obstetrics & Gynecology 94, 1178-1185.

155.Van Raaij, J.A., Schonk, C.M., Vermaat-Miedema, S.H., Peek, M.E.M., & Hautvast, J.G.A.J. (1990). Energy cost of walking at a fixed pace and self-paced before, during, and after pregnancy. American Journal of Clinical Nutrition 51, 158-161.

156.Simpson, J.L. (1993). Are physical activity and employment related to preterm birth and low birth weight? American Journal of Obstetrics & Gynecology 168(4), 1231-1238.

157.Feiberg, J.S., & Kelley, C.D. (1996). The pregnant worker: How much is too much? Assessing safe activity levels. Hawaii Medicine Journal 55, 85-86.

158.McDonald, A.D., McDonald, J.C., Armstrong, B., Chery, N.M., & Nolin, A.D. (1988). Prematurity and work in pregnancy. British Journal of Internal Medicine 45, 56-62.

159.Ramirez, G., Grimes, R.M., Annegers, J.F., Davis, B.R., & Slater, C.H. (1990). Occupational physical activity and other risk factors for preterm birth among US army primigravidas. American Journal of Public Health 80, 728-729.

160.Woodward, S.L. (1981). How does strenuous maternal exercise affect the fetus? A review. Birth and Family Journal 8, 17-24.

161.Briend, A. (1980). Maternal physical activity, birth weight and perinatal mortality. Medicine Hypotheses 6, 1157-1170.

Appendices

When complete please return this two day diary with your three day diet record in the Freepost addressed envelope provided

MASSEY UNIVERSITY

Department of Biochemistry in conjunction with the Ministry of Health

NUTRITION IN PREGNANCY STUDY

Two Day Activity Diary

Month Seven

ACTIVITY RECORD

1. There is one sheet for each 24 hour period.

2. You can start your record at any hour.

3. There is a row for each hour and each hour is divided into 10 minute blocks. Write in each block what you were doing for most of the time in that 10 minutes.

4. If you were doing anything for a long period of time e.g. sleeping, just write "sleep" in the first square and an arrow to when you finished sleeping.

5. Carry the record with you at all times and record all your activities as they change.

6. Make sure you fill in your activities for every hour on the page e.g. you may start your record at 7am Monday and finish at 7am Tuesday. This means you will start near the bottom of the page. You then go back to the top of the page and continue down the page making sure you record every hour.

NOTE:

(i) Record any activity you are doing fast as this increases your energy expenditure e.g. walk fast.

(ii) If you do housework or gardening note what exactly you are doing as energy expenditure varies with the activity.

(iii) Record sports etc. separately by name e.g. netball, aerobics, jogging.

e.g.

		10	20	30	40	50	
9	sit →		housework, sweeping →		making beds →		10
10	walk	hanging out washing →		sit →		stand & walk	11
11	drive car	shopping walking →			drive car	unpack shopping	12

Month Seven

Date: ______________ Code No. ______________

Time	MINUTES						Time
	10	20	30	40	50		
9am							10am
10am							11am
11am							12pm
12pm							1pm
1pm							2pm
2pm							3pm
3pm							4pm
4pm							5pm
5pm							6pm
6pm							7pm
7pm							8pm
8pm							9pm
9pm							10pm
10pm							11pm
11pm							12am
12am							1am
1am							2am
2am							3am
3am							4am
4am							5am
5am							6am
6am							7am
7am							8am
8am							9am

Month Seven

Date: ______________ Code No. ______________

Time	MINUTES 10	20	30	40	50		Time
9am							10am
10am							11am
11am							12pm
12pm							1pm
1pm							2pm
2pm							3pm
3pm							4pm
4pm							5pm
5pm							6pm
6pm							7pm
7pm							8pm
8pm							9pm
9pm							10pm
10pm							11pm
11pm							12am
12am							1am
1am							2am
2am							3am
3am							4am
4am							5am
5am							6am
6am							7am
7am							8am
[illegible]							9am

NUTRITION IN PREGNANCY STUDY
24 HOUR ENERGY EXPENDITURE ANALYSIS SHEET
SECOND TRIMESTER DAY 2

Code No. ____

Date ____

ACTIVITY	Time in minutes spent on each activity during each hour of the day																								Total minutes spent on each activity
	5 - 6 pm	6 - 7 pm	7 - 8 pm	8 - 9 pm	9 - 10 pm	10 - 11 pm	11 - 12 pm	12 - 1 am	1 - 2 am	2 - 3 am	3 - 4 am	4 - 5 am	5 - 6 am	6 - 7 am	7 - 8 am	8 - 9 am	9 - 10 am	10 - 11 am	11 - 12 am	12 - 1 pm	1 - 2 pm	2 - 3 pm	3 - 4 pm	4 - 5 pm	
Sleep/Lie																									
Sit																									
Stand																									
Stand and Walk slow																									
Walk																									

Time spent - light activity ____________ mins

- moderate activity ____________ mins
- heavy activity ____________ mins
- very heavy activity ____________ mins
- unduly heavy activity ____________ mins

TOTAL ____________ mins

Total Minutes ____________

Study Code Number

.BABY'S BIRTH DETAILS

These details will be recorded in your baby's Health and Development book.

NAME OF BABY:

BOY/GIRL:

WEIGHT:

LENGTH:

HEAD CIRCUMFERENCE:

APGAR SCORE: at 1 minute

at 5 minutes

DATE OF BIRTH:

WHAT WAS DUE DA TE:
(this to tell us if baby was early or late)

ETHNIC GROUP OF FATHER:

PLEASE RETURN IN FREE POST ENVELOPE.

NUTRITION IN PREGNANCY STUDY

ACTIVITY ANALYSES QUESTIONNAIRE

Code Number Subject : ____________

Date of Interview : ________________

Time of Interview : _______________

Diet record

4th month ____

7th month ____

Activity Diary

4th month ____

7th month ____

Birth Details

____

Well, I need to ask you a few questions about the birth of ____________

Before Administering Questionnaire

SAY: Anything that you tell me is in confidence and will remain confidential. Your name will not appear on any forms. If you do not want to answer a particular question just say so at the time.

1. Did your labour start naturally or was it started or assisted by a midwife or a doctor?

   Write down : ______________________________

Spontaneous = 1
Induced =2
Started naturally but stopped and induced = 3
Elective Caesarean = 4
Other = 7
Don't know = 8

____

2. Did you have any of the following during labour?

Yes = 1
No = 0
NA = 8

Syntocinon or pessaries	Yes / No	Syntocinon =	___
Injection for pain relief	Yes / No	Pethedine =	___
Gas and Air (mask for pain relief)	Yes / No	Gas =	___
Epidural (spinal injection for pain relief)	Yes / No	Epidural =	___
Other	Yes / No	Other =	___
Don't know	____	Don't know =	___

3. During pregnancy did you have drugs to stop labour (if the baby was premature) ______	Yes = 1 No = 0 ____
4. Did you require any of the following during the birth: Forceps ______ Caesarian ______ Episiotomy (stitches) ______ Other ______ Don't know ______	Forceps = 1 Caesarean = 2 Episiotomy = 3 Other = 4 NA = 8 Don't know = 9 ____
5. How long was your labour? Write down : ______	Length of labour ______ hrs
6. Was your baby in the special care/neonate unit at the hospital at any stage? Yes ____ No ____ Length of stay ______ days If yes, what for? Write down : ______	Yes = 1 No = 0 ____ No. of days ____

7. Did you at any time during the pregnancy have

	Yes/No	When	Length	Medication	Hospitalisation
Diabetes					
High BP					
Toxaemia					
Swelling					
Low Iron					
Asthma					

Yes/No	When	Length	Medication	Hospitalisation
Yes = 1				
No = 0	1-3 mo = 1	< 1 wks = 1	Yes = 1	Yes = 1
	4-6 mo = 2	1-2 wks = 2	No = 0	No = 0
	7-9 Mo = 3	3-4 wks = 3		
		4-8 wks = 4		
		> 8 wks = 5		

Coding Table

	Yes/No	When	Length	Medication	Hospitalisation
Diabetes					
High BP					
Toxaemia					
Swelling					
Low Iron					
Asthma					