Original Research

COMPARISON OF BLOOD LIPIDS, BMI LEVELS AND HBA1C LEVELS AMONG VEGANS, OVO-LACTO VEGETARIANS AND OMNIVORES

Stephanie Bond, Pounamu Gardiner, Megan Gibbons, Richard Humphrey and Pete Eley

INTRODUCTION

Lifestyle diseases are becoming a growing epidemic within New Zealand. The average New Zealander has a cholesterol level of 5.7 mmol/L – significantly higher than the Heart Foundation's recommended levels of less than 4.0 mmol/L (The Heart Foundation NZ).. Meanwhile, more than seven percent of New Zealanders have diabetes (Maori Diabeties NZ). This is consistent with global upward trends in the number of diabetes cases.

Both lifestyle diseases are firmly rooted to diet. Many foods consumed in New Zealand, such as fatty meats, full fat dairy products, biscuits, cakes, pastries and fried takeaways are high in saturated fats, which raise cholesterol levels (National Cholesterol Education Program NZ). This dietary pattern is one of the most important dietary risk factors for obesity and other lifestyle diseases (Lee & Krawinkel, 2009).

In this study, blood lipids, BMI and HbA1c were compared to determine which dietary category was most beneficial in preventing lifestyle diseases. Blood lipids are all the fatty substances in the blood including cholesterol and triglycerides (National health Service Report UK). BMI is calculated by dividing weight in kilograms by the square of height in metres (kg/m2), and provides a measure of weight adjusted for height (www.health.govt.nz). HbA1c measures average blood glucose over the previous four to six weeks (Diabetes NZ).

To offer clarification on the differences between the three dietary groups, adherence to a vegan diet excludes eggs, milk, meat, poultry, seafood and by-products of animal slaughter. An ovo-lacto vegetarian diet excludes meat, seafood and poultry, while omnivores consume both plant and animal products (Huang et al., 2014; Larsson & Johansson, 2002).

While the downsides of an omnivorous diet rich in saturated fat are well documented, so too are the factors in favour of a vegetarian diet, also known as ovo-lacto vegetarianism (Chaudhuri et al., 2013; Tonstad et al., 2009). However, evidence for the health benefits of a vegan diet in preventing lifestyle diseases is not as readily available.

As a result, a research gap exists in analysing the benefits of each diet and assessing whether one is more effective than another in achieving better health. Filling this gap is important, as it may help inform the public to make better decisions about the food they eat. The only relevant study conducted in Otago was published over 15 years ago (Harman & Parnell, 1999). The following section describes the nutritional status of vegetarians and vegans, before discussing the methods, results and analysis of the study.

Nutritional status of vegetarians and vegans

The Ministry of Health states that a vegetarian (including vegan) can get all their essential nutrients from food without eating animal products (www.healthed.govt.nz). Vegetarian diets are usually rich in carbohydrates, n-6 fatty acids, fibre, carotenoids, folic acid, vitamin C, vitamin E and magnesium, and relatively low in protein, saturated fat, long chain n-3 fatty acids, retinol, vitamin B12 and zinc. Vegans may have low intakes of vitamin B12 and calcium (Key, Appleby, & Rosell, 2006). Vegetarian diets are associated with health benefits because of their high fibre content and reduced saturated fat content. Vegan diets contain less saturated fat and cholesterol and are usually higher in iron and dietary fibre whilst containing fewer calories (Craig, 2009). A matched samples study which investigated the nutritional status of vegetarians and omnivores found that total energy intake was not significantly different between dietary categories. Vegetarians had lower sodium intake and higher calcium, zinc and iron intake compared with non-vegetarians (Deriemaeker et al., 2010). Individuals following plant-based diets typically consume fewer calories, less saturated fat and cholesterol and have lower BMIs than non-vegetarians. They also consume more fibre, potassium and vitamin (Trapp & Levin, 2012). Vegetarians usually consume more fruits and vegetables than omnivores while restricting animal products, providing a lower intake of saturated fatty acids and increased fibre compared to omnivores (Kim, Cho & Park, 2012).

Blood Lipids

Previous studies have shown that individuals consuming vegetarian or vegan diets have lower blood lipid levels, especially LDL and TG, compared with omnivores. When comparing TC, LDL, HDL and TG between vegetarians and omnivores, vegetarian diets were associated with lower levels (De Biase et al., 2007). A review of 27 randomised controlled and observational trials concluded that plant-based eating patterns including nuts, soy and/or soluble fibre can reduce LDL levels by 25-30%, an amount comparable to cholesterol-lowering drugs (Ferdowsian & Barnard, 2009). A 2012 study indicated that long-term vegetarians had significantly lower blood lipid levels than omnivores (Kim, Cho & Park, 2012). Low-fat, plant-based diets have shown effectiveness in reducing LDL levels and result in significant reductions in cardiovascular events and disease risk (Trapp & Levin, 2012). A study of lipid profiles of vegetarian and non-vegetarian women found increases in TC, TG, LDL and cholesterol/HDL ratio in women on the non-vegetarian diet (Chaudhuri et al., 2013). In contrast, a study comparing lipid profiles of female vegans, ovo-lacto vegetarians and omnivores showed that vegans had significantly lower HDL and higher TG, LDL and TC compared with omnivores (Huang et al., 2014). A hospital-based survey of healthy adults showed that vegetarians had lower TC and LDL levels than omnivores, demonstrating that the consumption of a vegan diet or ovo-lacto vegetarian diet lowers cardiovascular disease risk (Chen et al., 2007).

BMI

Studies of Western vegetarians have consistently reported that vegetarians have lower BMIs than comparable non-vegetarians, and that the proportion of vegetarians who are obese is correspondingly lower than that among non-vegetarians (Key, Appleby, & Rosell, 2006). In contrast, Lee et al. discovered that vegetarians had significantly higher body weight and BMI than omnivores; the median BMI of both vegetarians and omnivores fell into the normal range (22.6 vs 20.7 kg/m2). The prevalence of underweight (BMI < 18.5 kg/m2) cases in the omnivore group was higher than the vegetarian group, while the vegetarians showed tendencies of pre-obesity (25.0-29.9 kg/m2; Lee & Krawinkel, 2009). A 2009 study found that mean BMI was lowest in vegans (23.6 kg/m2), slightly higher in lacto-ovo vegetarians (25.7 kg/m2) and highest in non-vegetarians (28.8 kg/m2; Tonstad et al., 2009). The protective effects of vegetarian diets against being overweight may be due to avoidance of major food groups or displacement of calories toward more satiating food groups (Tonstad et al.). Kim et al. found that the median BMIs of vegetarians were lower than those of omnivores, and that body fat was significantly lower in vegetarians (21.6%) than in omnivores (25.4%;

Kim, Cho & Park, 2012). In observational studies, vegans and vegetarians are slimmer than non-vegetarians. When vegan and vegetarian diets are used in clinical trials, they produce significant weight loss. Notably, weight loss occurs in the absence of intentional calorie restriction even when exercise remains constant (Trapp & Levin, 2012). A large study cited by Kim et al. involving 38,000 participants showed that, in comparison to meat-eaters who consume a small amount of fibre, vegetarians (particularly vegans) have significantly lower BMIs (Kim, Cho & Park, 2012). Significant increases in BMI were also found in women consuming a non-vegetarian diet (Chaudhuri et al., 2013).

HbA1c

The World Health Organization projects that diabetes will be the seventh leading cause of death in 2030 (World Health Organization). In 2004, an estimated 3.4 million people died from consequences of high fasting blood sugar levels (WHO). A 2006 study that matched vegetarians and non-vegetarians found that non-vegetarians had higher insulin and glucose values (Valachovičová et al., 2005). Three biological factors may explain why a low-fat, plant-based diet can be effective for glycemic control: foods from plants contain less total and saturated fat, resulting in reduced caloric intake, weight loss and improved A1c levels (Barnard et al., 2006). Several observational studies have shown that the overall glycemic load and/or glycemic index of a diet is positively associated with the risk of type 2 diabetes (Waldmann, 2007). Tonstad et al. discovered that as consumption of animal products increased, so did the prevalence of diabetes, ranging from 2.9% in vegans to 7.6% among individuals with unlimited consumption of animal products (Tonstad et al., 2009). A plant-based diet can reduce the risk of developing type 2 diabetes and, for individuals who already have diabetes, a low-fat, plant-based approach has shown effectiveness for metabolic control (Trapp & Levin, 2012).

METHODS

Participants

The first 20 individuals who made contact in each dietary category, and who met the inclusion and exclusion criteria, were selected as participants.

Data Collection

Anthropometric measurements using segmental multi-frequency-bioelectrical impedance analysis (Tanita BC-418). Height was measured to the nearest 0.1cm. BMI of the participants who had fasted overnight was calculated by the Tanita BC-418, which measures body composition using high-frequency current (50 kHz; www.tanita.com).

Blood sampling, lipid profile measurements and HbA1c measurements. Finger-prick blood samples were collected using a single-use, disposable blood lancet and results read by the Cobas b 101 instrument.

Data analysis

The Cobas b 101 instrument has specific measuring ranges for TC (1.28 – 12.95 mmol/L), TG (0.50 – 7.35 mmol/L) and HDL (0.38 – 2.60 mmol/L). LDL results are a calculated value which uses the Friedwald formula (LDL = TC – HDL – TG/2.17; Friedwald, Levy & Fredrickson, 1971). If a TC, TG or HDL result was out of the measuring range, 'Hi' or 'Lo' was displayed. To obtain a numerical figure, a number was entered just outside of the measuring range. Where a 'Lo' result was indicated for TG, a result of 0.49 was entered. Where a 'Hi' result was indicated for HDL, a result of 2.61 was entered. Where LDL could not be determined by the Cobas b 101 instrument, a result of 'N/A' was displayed and a numerical figure was obtained using the Friedwald formula.

A one-way between dietary groups multivariate analysis was performed to investigate dietary differences in TC and HbA1c. Two independent variables were used – TC and HbA1c. The independent variable was diet. This was broken down into vegan, ovo-lacto vegetarians and omnivores. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance–covariance matrices, and multicollinearity, with no serious violations observed.

RESULTS

Selected characteristics, mean BMI, TC and HbA1c of each dietary group is shown in Table 1. Sixty-one participants were tested. In the vegan dietary category, the mean age was 27.1 years with a ratio of 6:13 male to female, mean BMI = 24.20, mean TC = 4.22 and mean HbA1c = 31.84mmol. In the ovo-lacto vegetarian dietary category, mean age = 28.5 years with a ratio of 4:18 male to female, mean BMI = 22.55, mean TC = 4.50 and mean HbA1c = 32.45mmol. In the omnivorous dietary category, mean age = 25.8 with a ratio of 5:15 male to female, mean BMI = 25.11, mean TC = 4.52 and mean HbA1c = 33.30mmol.

.

Variable	Vegan n= 19	Ovo-Lacto Vegetarian n=22	Omnivore n= 20
Age Mean (s.d)	27.1	28.5	25.8
Male:Female	6:13	4:18	5:15
BMI Mean (s.d)	24.20	22.55	25.11
Total cholesterol Mean (s.d)	4.22	4.50	4.52
HbA1c Mean (s.d)	31.84	32.45	33.30

Table 1. Characteristics and BMI, total cholesterol and HbAlc by diet group

Physical Activity Category	Number
None	3
1-2 per week	5
2-4 per week	21
5-6 per week	17
7+ per week	15

Table 2. Physical activity frequency per week.

Education level	Number
High School	18
Tertiary Certificate	5
Tertiary Diploma	6
Tertiary Bachelor's Degree	22
Tertiary Master's Degree	10

Table 3 Highest education level.

There was no statistical difference between vegans (n=19), ovo-lacto vegetarians (n=22) and omnivores (n=20) on the combined dependent variables, $F(4, 114) = 1.01$, $p = .405$; Wilks Lambda = .933; partial eta squared = .034. No differences reached statistical significance.

DISCUSSION

This study showed that a vegan, ovo-lacto vegetarian or omnivorous diet had no statistically significant effect on blood lipids, BMI or HbA1c levels. In this sample group of 61 participants, the mean age was 27.1 in the vegan dietary category, 28.5 in the ovo-lacto vegetarian group, and 25.8 in the omnivorous dietary category. This may be due to the age inclusion criteria of 18-45 and a sizeable proportion of the subjects being students (60.05%). The study was conducted in Dunedin, New Zealand – a university city that has a mean age of 35.0 years, lower than the national mean age of 35.9 (www.stats.govt.nz). A national survey of New Zealanders' health found that Dunedin residents consume the second-lowest amount of takeaways. Just 19% of Dunedinites ate fast food two or more times every week, compared to 34% of Aucklanders (www.southerncross.co.nz). Our study was similar, with only 18% of participants consuming takeaways one to two times per week or more. Further research which compares dietary categories across different regions of New Zealand is justified.

Our findings showed no significant difference in BMI between the dietary categories. This opposes a study which had a sample size of 1694 participants and where their mean BMI differed significantly between dietary groups; vegans had a lower mean BMI, with a much higher proportion of vegans having a BMI less than 20 (Bradbury et al., 2013). Other studies of Western vegetarians have reported that vegetarians have lower BMIs than comparable non-vegetarians (Key, Appleby, & Rosell, 2006; Tonstad et al., 2009). Trapp et al. (2012) and Chaudhuri et al. (2013) had similar findings, with vegans and vegetarians being slimmer than their meat-eating counterparts. However, a valid discussion point is that BMI is not a perfect measure of body composition (Bradbury et al.). Future studies comparing dietary categories should investigate more detailed body composition measures such as body fat percentage.

One limitation of our sample group could be due to participants being interested in their health and obtaining a free health screening. Our participants could reflect a sample of healthy, young individuals. As well as no statistically significant differences in BMI, there was no statistical difference in blood lipid levels between the dietary categories. The mean total cholesterol levels across all groups in our study (vegan = 4.22 mmol/L, ovo-lacto vegetarian = 4.50 mmol/L and omnivore = 4.52 mmol/L) were lower than the New Zealand average of 5.7 mmol/L (www.ncepnz.co.nz). A 1998 study compared vegetarians and omnivores and found that lipid levels for both dietary groups were lower than what could be observed for the New Zealand population. No significant differences in blood lipids between the two dietary groups were found (Harman & Parnell, 1999). A cross-sectional study comparing blood lipids among vegans and vegetarians found that vegans had a significantly lower HDL level than omnivores; however, all other lipid levels were comparable to an omnivorous diet (Huang et al., 2014).

Our participants were very physically active; 34.42% exercised three to four times per week, 27.86% five to six times, and 24.59% exercised seven or more times per week. Only 4.91% of participants did not participate in any weekly exercise. South Islanders are much more likely to be physically active (73%) than the national average (54%; Ministry of Health NZ). Physically inactive people are more likely to develop heart disease and diabetes, for which blood lipids and HbA1c are precursors (Ministry of Health NZ). A 2012 study investigating the effects of exercise on blood lipids in persons with varying dietary patterns found that, independent of diet, exercise had a beneficial effect on blood lipids (Huffman et al., 2012).

Reports from cross-sectional studies provide compelling evidence for the positive influence of physical activity and exercise on blood lipids (Durstine et al., 2001). Blood lipid profiles of physically active groups reflect a reduced risk of cardiovascular disease when compared with their inactive counterparts (Durstine et al.). However, the same authors also suggest that those who are physically active exhibit lower levels of TC and LDL than those who are less active. Further research comparing active and inactive vegans, ovo-lacto vegetarians and omnivores, determining if both dietary group and physical activity contribute to a lower blood lipid profile, is warranted.

All participants had normal HbA1c levels. HbA1c measures the average blood glucose over the previous four to six weeks, with less than 53 mmol/L being very healthy (Diabetes New Zealand). Both aerobic and resistance exercise are associated with decreased risk of type 2 diabetes (Warburton, 2006). Each increase of 500 kcal (2100 kJ) in weekly energy expenditure is associated with a decreased incidence of type 2 diabetes of 6% (Helmrich et al.,1991). A high proportion of our sample was regularly physically active, which may have contributed to their healthy HbA1c levels.

Education level may have also influenced healthy blood lipids and HbA1c levels; 70.49% of participants held tertiary level qualifications, with 36% having bachelors degrees and 16% having masters. Individuals with higher education have reported less acute and chronic diseases such as heart disease, diabetes, raised cholesterol and strokes (Cutler & Lleras-Muney, 2006). The magnitude of the relationship between education and health is varied but large; completing an additional four years of education reduces the risk of heart disease by 2.16% and diabetes by 1.3% (Cutler & Lleras-Muney).

CONCLUSION

There were no findings of statistical significance when comparing blood lipids, BMI or HbA1c among vegans, ovo-lacto vegetarians and omnivores in this study. Our results suggested that following a vegan, ovo-lacto vegetarian or omnivorous diet had comparable benefits in preventing lifestyle diseases. Physical activity levels, age, education and region may have been confounding factors that influenced the results. Further research comparing physical activity, education and region among each dietary category is warranted.

Stephanie Bond obtained her Bachelor of Applied Science from Otago Polytechnic in Dunedin 2015. Steph is currently a Bachelor of Nursing student at Otago Polytechnic. Her research interests include nutrition, physical activity and health promotion.

Pounamu Gardiner is a 2015 graduate of Otago Polytechnic, where she completed a Bachelor of Applied Science (Physical Activity, Health and Wellness).

Megan Gibbons is the head of college at Te Ohu Ora, which includes the Institute of Sport and Adventure and the School of Occupational Therapy at Otago Polytechnic. She has a PhD from Auckland University. Megan's research interests include workplace health and wellness, and paediatric and micronutrient nutrition. Recently she has become interested in understanding the learner in the tertiary setting and how teachers can best meet their needs and expectations. Megan is of Ngā Puhi descent and is married with two school-aged children. She has multiple sporting commitments and is an athletics coach for both national development teams and Otago athletes.

Richard Humphrey began his academic career at the University of Southampton (UK), where he taught sport studies and sport management and development. Following some postgraduate study at the University of Bristol, he emigrated to New Zealand in 2013 and took up a lecturing position at the Institute of Sport and Adventure at Otago Polytechnic. Richard teaches and supervises undergraduate research in the fields of exercise, health and research methods. His research interests include the therapeutic use of exercise and substance misuse, particularly in the case of people with coexisting mental health issues.

Peter Eley has spent the last 20 years blending his passion for the outdoors with a passion for education. During this time, he has carved out a niche for himself at Otago Polytechnic, where he has worked as a lecturer for the past 13 years. He continues to teach in the outdoors, but is also involved in student training and research supervision in the health and wellness area at the Polytechnic.

Correspondence to: Steph Bond, College Te Oha Ora, Sargood Centre, Otago Polytechnic, 40 Logan Park Drive, Dunedin 9016, New Zealand. Email: steph007_nz@yahoo.com

REFERENCES

Barnard, N. D., Cohen, J., Jenkins, D. J.a., Turner-Mcgrievy, G., Gloede, L., Jaster, B., Seidl, K., Green, A. A. & Talpers, S. A Low-Fat Vegan Diet Improves Glycemic Control and Cardiovascular Risk Factors in a Randomized Clinical Trial in Individuals with Type 2 Diabetes. *Diabetes Care,* 29(8),1777-783.

Bradbury, K. E., Crowe, F. L., Appleby, P. N., Schmidt, J. A., Travis, R. C., & Key, T. J. (2015). Serum concentrations of cholesterol, apolipoprotein AI and apolipoprotein B in a total of 1694 meat-eaters, fish-eaters, vegetarians and vegans. *European Journal of Clinical Nutrition*, 69(10), 1180-1181.

Chaudhuri, A., Borade, N., Bandopadhyay, A., Hazra, S., Saha, S., & Mondol, S. A. (2013). *Comparative Study of Lipid Profile and Autonomic Functions in Vegetarian and Non-Vegetarian Postmenopausal Women. Medical Journal of Dr. D.Y. Patil University*, 6(1), 60.

Chen, C-W, Lin, Y-L., Lin, T-K., Lin, C-T., Chen, B-C., & Lin, C-L. (2007). Total Cardiovascular Risk Profile of Taiwanese Vegetarians. *European Journal of Clinical Nutrition,* 62(1),138-44.

Craig, W. J. (2009). Health Effects of Vegan Diets. *American Journal of Clinical Nutrition* 89(5).

Cutler, D. & Lleras-Muney, A. (2006). Education and Health: Evaluating Theories and Evidence. (No. w12352). *National Bureau of Economic Research.*

De Biase, S. G., Fernandes, S. F. C., Gianini, R. J., & Duarte, J. L. G. (2007). Vegetarian diet and cholesterol and triglycerides levels. *Arquivos brasileiros de cardiologia,* 88(1), 35-39.

Deriemaeker, P., Alewaeters, K., Hebbelinck, M., Lefevre, J., Philippaerts, R., & Clarys, P. (2010). Nutritional status of Flemish vegetarians compared with non-vegetarians: a matched samples study. *Nutrients,* 2(7), 770-780.

Diabetes New Zealand. (2014). New Zealand Diabetes Statistics. Accessed October 2014. http://www.diabetes.org.nz/resources/facts_and_figures.

Diabetes New Zealand. (2014). *Staying Well with Type 2 Diabetes*. Accessed October 2014 from http://www.diabetes.org.nz/__data/assets/pdf_file/0013/3802/2014_Staying_well_with_type_2.pdf.

Diabetes New Zealand. (2015). *Lab Tests & Type 1 Diabetes.* Accessed September 2015. http://www.diabetes.org.nz/living_well_with_diabetes/living_with_type_1_diabetes/lab_tests.

Diabetes.co.uk. Diabetes *Risk Factors.* Accessed October 2014. http://www.diabetes.co.uk/Diabetes-Risk-factors.html.

Durstine, J., Peter, L., Grandjean, W., Davis, P. G., Ferguson, M. A., Alderson, N. L., & Dubose, K. D. (2001). Blood Lipid and Lipoprotein Adaptations to Exercise. *Sports Medicine* 31(15),1033-062.

Ferdowsian, H. R., & Barnard, N. D. (2009). Effects of Plant-Based Diets on Plasma Lipids." *The American Journal of Cardiology,* 104(7), 947-56.

Friedewald, W. T., Levy, R. I., & Fredrickson, D. S. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical chemistry,* 18(6), 499-502.

Fung, T. T., Schulze, M., Manson, J. E., Willett, W. C., & Hu, F. B. (2004). Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Archives of internal medicine*, 164(20), 2235-2240.

Harman, S. K., & Parnell, W. R. (1998). The nutritional health of New Zealand vegetarian and non-vegetarian Seventh-day Adventists: selected vitamin, mineral and lipid levels. *The New Zealand Medical Journal,* 111(1062), 91-94.

Helmrich, S. P., Ragland, D. R., Leung, R. W., & Paffenbarger Jr, R. S. (1991). Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. *New England journal of medicine*, 325(3), 147-152.

Huang, Y. W., Jian, Z. H., Chang, H. C., Nfor, O. N., Ko, P. C., Lung, C. C., ... & Liaw, Y. P. (2014). Vegan diet and blood lipid profiles: a cross-sectional study of pre- and post-menopausal women. *BMC women's health*, 14(1), 55.

Huffman, K. M., Hawk, V. H., Henes, S. T., Ocampo, C. I., Orenduff, M. C., Slentz, C. A., Johnson, J. L., Houmard, J. A., Samsa, G. P., Kraus, W. E., & Bales, C. W. (2012). Exercise effects on lipids in persons with varying dietary patterns—does diet matter if they exercise? Responses in Studies of a Targeted Risk Reduction Intervention through Defined Exercise I. *American heart journal,* 164(1), 117-124.

Key, T. J., Appleby, P. N., & Rosell, M. S. (2006). Health effects of vegetarian and vegan diets. *Proceedings of the Nutrition Society*, 65(1), 35-41.

Kim, M. K., Cho, S. W., & Park, Y. K. (2012). Long-term vegetarians have low oxidative stress, body fat, and cholesterol levels. *Nutrition research and practice,* 6(2), 155-161.

Larsson, C. L., & Johansson, G. K. (2002). Dietary intake and nutritional status of young vegans and omnivores in Sweden. *The American journal of clinical nutrition*, 76(1), 100-106.

Lee, Y. J., & Krawinkel, M. (2009). Body composition and nutrient intake of Buddhist vegetarians. *Asia Pacific journal of clinical nutrition*, 18(2), 265-271.

Ministry of Health New Zealand (2014). Eating for Healthy Vegetarians. Accessed August 2014. https://www.healthed.govt.nz/system/files/resource-files/7561.pdf.

Ministry of Health New Zealand (2015). Sit Less, Move More. Accessed September 2015. http://www.health.govt.nz/your-health/healthy-living/food-and-physical-activity/physical-activity/sit-less-move-more.

Ministry of Health New Zealand. (2014). Obesity Questions and Answers. Accessed August 2014. http://www.health.govt.nz/our-work/diseases-and-conditions/obesity/obesity-questions-and-answers.

Ministry of Health NZ (2017). Body Size. Accessed May 29, 2017. http://www.health.govt.nz/our-work/populations/maori-health/tatau-kahukura-maori-health-statistics/nga-tauwehe-tupono-me-te-marumaru-risk-and-protective-factors/body-size.

Ministry of Health NZ. (2015). Regional Results from the 2011/12 New Zealand Health Survey. Accessed September 2015. http://www.health.govt.nz/publication/regional-results-2011-12-new-zealand-health-survey.

National Cholesterol Education Programme New Zealand. *What is Cholesterol?* Accessed August 2014 from http://www.ncepnz.co.nz/about.html.

National Heart Foundation of New Zealand. (2015). *High Cholesterol.* Accessed September 2015. https://www.heartfoundation.org.nz/know-the-facts/conditions/high-cholesterol.

NHS Greater Glasgow and Clyde. (2017). *High Blood Lipids (Fats)*. Accessed May 29, 2017. http://www.nhsggc.org.uk/your-health/health-services/hsd-patient-carers/heart-disease/risk-factors-for-heart-disease/high-blood-lipids-fats/.

Southern Cross Health Society. (2015). Dunedin is One of the Healthiest Places to Live in NZ, According to Survey. Accessed September 2015. https://www.southerncross.co.nz/Portals/0/Group/Corporate/Dunedin%20is%20one%20of%20the%20healthiest%20places%20to%20live%20in%20NZ.pdf. 2011

Statistics New Zealand. (2015). Quick Stats About Dunedin City. Accessed September 2015. http://www.stats.govt.nz/Census/2006CensusHomePage/QuickStats/AboutAPlace/SnapShot.aspx?tab=Agesex&id=2000071.

Tanita. (2014) BC-418 *Segmental Body Composition Analyser.* Accessed August 2014 from www.tanita.com/en/bc-418/

Tonstad, S., Butler, T., Yan, R., & Fraser, G. E. (2009). Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. *Diabetes care*, 32(5), 791-796.

Trapp, C., & Levin, S. (2012). Preparing to prescribe plant-based diets for diabetes prevention and treatment. *Diabetes Spectrum*, 25(1), 38-44.

Valachovičová, M., Krajčovičová-Kudlačková, M., Blažíček, P., & Babinská, K. (2006). No evidence of insulin resistance in normal weight vegetarians. *European journal of nutrition,* 45(1), 52-54.

Waldmann, A., Ströhle, A., Koschizke, J. W., Leitzmann, C., & Hahn, A. (2007). Overall glycemic index and glycemic load of vegan diets in relation to plasma lipoproteins and triacylglycerols. *Annals of Nutrition and Metabolism*, 51(4), 335-344.

Warburton, D. E. (2006). Health Benefits of Physical Activity: The Evidence. *Canadian Medical Association Journal* 174(6), 801-09.

World Health Organization (2014). Diabetes. Accessed October 2014. http://www.who.int/mediacentre/factsheets/fs312/en/.