

An exploration of physical activity, nutrition, and body size in Pacific children

Melody Oliver^{1,2,5§}, Elaine Rush², Philip Schluter^{1,3,4}, Gerhard Sundborn^{1,5,6}, Leon Iusitini^{1,5}, El-Shadan Tautolo^{1,5}, Janis Paterson^{1,5}, James Heimul⁷

¹ National Institute for Public Health and Mental Health Research, AUT University, Auckland, New Zealand

² Centre for Physical Activity and Nutrition, AUT University, Auckland, New Zealand

³ The University of Queensland, School of Nursing and Midwifery, Qld 4072, Australia

⁴ Department of Public Health & General Practice, University of Otago, Christchurch, New Zealand

⁵ Centre for Pacific Health and Development Research, AUT University, Auckland, New Zealand

⁶ University of Auckland, School of Population Health, Auckland New Zealand

⁷ Pasifika Medical Association, Manukau, New Zealand

§ **Corresponding author:**

Dr Melody Oliver, Mail #A-24, Centre for Physical Activity and Nutrition, Auckland University of Technology,
Private Bag 92006, Auckland 1142, New Zealand
Telephone +64 9 921 9999; Fax +64 9 921 9746; E-mail: melody.oliver@aut.ac.nz

Introduction

In New Zealand the number of Pacific people is rapidly growing and currently represents 7% of the total population; with two thirds living in the Auckland region, around half aged less than 21 years, and 97.5% living in urban areas.¹ By 2026, the proportion of Pacific people in New Zealand is projected to increase to 10%, driven mainly by a relatively high birth rate.² The Pacific population group exhibits significantly poorer health outcomes compared to other ethnic groups in New Zealand, including higher rates of morbidity and mortality associated with chronic diseases such as cardiovascular disease, type 2 diabetes, obesity, and some cancers.³⁻⁸

In recent years, the number of deaths that could be avoided by timely health care (amenable mortality) has declined in both the general and the Pacific population.⁹ The improvement in amenable mortality for Pacific people, however was less than any other ethnic group.¹⁰ After accounting for age, cardiovascular disease and type 2 diabetes are the predominant contributors to amenable mortality in New Zealand,⁹ with stroke and type 2 diabetes identified as two of the top ten conditions that help explain loss of quality of life and the number of disability adjusted life years (DALYs) lost.¹¹ Importantly, these diseases are also the key driver in absolute inequality observed for amenable mortality in Pacific people.⁹

Obesity is one of the most significant lifestyle-related diseases of the contemporary developed world,¹² and is intrinsically linked with risk for cardiovascular disease and type 2 diabetes. This risk for and complications of these diseases may be prevented or delayed across the life course by increasing physical activity and limiting prolonged, unhealthy nutrition. After the United States and Mexico, New Zealand has the highest rates of adult obesity in the Organisation for Economic Co-operation and Development group.¹³ New Zealand has also experienced a particularly high increase in childhood obesity prevalence in recent decades and now has one of the highest rates of obesity in school-aged children worldwide.¹⁴ In the 2006/2007 New Zealand Health Survey, nine out of 10 Pacific adults and nearly six out of ten Pacific children were classified as overweight or obese.¹⁵ These proportions reflect overweight and obesity levels of 31%



and 60% respectively in adults, and 29% and 26% respectively in children; rates that were substantially higher than the general population.¹⁵ Furthermore in children the prevalence increases with age. Recent data on Pacific youth has shown a higher level of obesity than in previous reports (36%), which remains considerably higher than their non-Pacific peers (Māori: 21%; New Zealand European/Other: 9%; Asian: 7%).¹⁶ These children are at significantly greater risk than their non-obese counterparts of experiencing associated negative health outcomes both during childhood and in later life, including presenting with type 2 diabetes and cardiovascular disease risk factors, and experiencing obstructive sleep apnoea, orthopaedic complications, and a reduced overall quality of life and psychological wellbeing.¹⁷⁻¹⁹ Obese children are also more likely to become obese adults and experience associated morbidities in later life.²⁰

Simplistically, obesity is predominantly the consequence of a “gap” in energy, i.e., the excess of energy intake over energy expenditure.²¹ The drivers behind this “gap” are complex however, and it is now acknowledged that an understanding of the development of obesity requires a life course perspective.²² The rate of growth and development of a child is determined by interactions of genes with the environment, and the first environment the child is exposed to is in the womb, prenatally determined by the nutrition and health of the mother.²³ Accordingly, improving nutrition across the entire life course, and physical activity in childhood and beyond, are key strategies for improving body size and health outcomes in all population groups.²⁴⁻²⁶

It has been estimated that 40% of all deaths in New Zealand could be attributed to sub-optimal nutrition and physical activity.²⁷ After smoking, physical inactivity is the leading risk factor for DALYs lost, followed by obesity, high blood cholesterol, and high blood pressure (all three of which are negatively associated with physical activity and healthy nutrition).¹¹ Although a dose response relationship has been established between physical activity and numerous health outcomes in general populations (with the reverse for sedentary behaviour), little is known with respect to Pacific people.^{26,28-38} This is primarily because, to date, self-report or proxy-report (e.g., parent report of their child’s activity) measures have been used to gather physical activity participation information in this population. This methodology is inadequate as it is inherently biased, and is influenced by issues such as social desirability, comprehension, and recall.^{39,40} The longitudinal Pacific Islands Families Study (PIFS) offers a unique opportunity to explore these issues in more detail, using objective information, and data collected over multiple life stages. This paper provides an exploration of nutrition and physical activity behaviours, and the association with body size and body fatness, in members of the PIFS.

Data sources

For the purposes of this examination, data are drawn from the PIFS; full details of which are provided elsewhere.^{41,42} Briefly, the PIFS cohort were recruited from live births at Middlemore Hospital in 2000, and assessments have been conducted with the children and their mothers when the children were aged 6 weeks, and 1, 2, 4, 6, 9, and 11 years of age. Fathers have also been interviewed at 1, 2, 6, and 11 years and teachers at 6, 9, and 11 years. The overarching aims of the PIFS are to: 1) Identify and characterise those individuals and families experiencing both positive and negative health outcomes, 2) Understand the mechanisms and processes shaping the pathways to those outcomes, and 3) Make empirically based strategic and tactical recommendations to improve the wellbeing of Pacific children and families and thereby benefit New Zealand society as a whole. Ethical approval for the PIFS and related studies has been obtained from the Auckland Branch of the National Ethics Committee, the Royal New Zealand Plunket Society and the South Auckland Health Clinical Board. Five key themes are considered in the current paper as follows:



1. Measures of food security for the mothers ($n = 1376$) approximately 6 weeks after the birth of their baby.⁴³ Food security can be defined as “access at all times to enough and nutritionally appropriate food to provide the energy and nutrients needed to maintain an active and healthy life”. Food security and dietary information was obtained using questions used in the 2002 New Zealand National Children’s Nutrition Survey.⁴⁴ Foods limited by lack of money were analysed by the number of calories for each dollar paid.
2. Food patterns of the child at four years.⁴⁵ At the four year measurement point the diet of 907 children was assessed by food frequency questionnaire and body composition by anthropometry (height, weight) and bioelectrical impedance analysis.
3. Growth of the child from birth to six years.^{46,47} Weight was measured at birth; body mass index (BMI; kg/m^2) was calculated from weight and height measured at 2 years, 4 years, and 6 years; and body fat percentage (%BF) was determined at 4 years and 6 years of age using bioelectrical impedance analysis. BMI status was classified using age and sex specific international thresholds.⁴⁸ Age-specific standard deviation scores (z-scores) for weight, height, and BMI were computed using the World Health Organization (WHO) growth standards⁴⁹ when the children were aged 4, and the Centres for Disease Control (CDC) 2000 growth curves when the children were aged 6.⁵⁰ When the children were aged 4 years, an examination was conducted for a sub-sample of the PIFS cohort ($n = 659$), comparing BMI z-scores with the WHO growth standards. Comparisons were made for those mothers who breastfed and did not smoke, versus those who smoked and did not breastfeed. When the children were aged 6 years, a similar investigation was conducted for 722 children who were full-term singleton births to mothers without known diabetes, comparing BMI Z-scores with the CDC 2000 growth curves.⁵⁰
4. Parental perceptions of overweight and obesity in their children.⁵¹ When the children were aged 4 years and 6 years, mothers were asked how concerned they were about their child becoming overweight. BMI status and %BF were determined as noted earlier. A total of 569 parent child dyads ($n = 299$ boys, 270 girls) were included in this study. The factors associated with parental perception were examined in a multivariable model using logistic regression. Factors examined included the sex of the child, acculturation, ethnicity, education, smoking, marital status, mothers age, household income, parity, and household size.
5. Objective physical activity patterns of the child and mother when the children were aged 6 years.⁵² In 2006, a subsample of children and their mothers ($n = 254$) were provided with an accelerometer (motion sensor), which was worn on a belt around the hip for the next eight days, to gain an objective assessment of their usual physical activity patterns. BMI status was measured and classified as above, and BMI z-scores were computed using the CDC growth curves.⁵⁰ Waist circumference was measured and classified as high or otherwise using New Zealand thresholds.⁵³ For mothers, ethnic-specific BMI thresholds for overweight ($27 \text{ kg}/\text{m}^2$) and obesity ($35 \text{ kg}/\text{m}^2$) were used to determine maternal weight status⁵⁴, and the ethnic-specific threshold for high waist circumference (98 cm) was applied.⁵⁵ Factors related to children’s moderate-to-vigorous intensity physical activity were investigated as follows: weather, child behaviour,⁵⁶ parenting style,⁵⁷ neighbourhood perceptions,⁵⁸ demographics, and maternal report of their child’s and family’s activity behaviours.⁵⁹ An exploration of factors related to BMI z-scores in the children was then conducted using bivariable and multivariable regression analyses.⁶⁰ Potential related factors were physical activity rate, sedentary behaviours, maternal body size, child birth weight, sleep time, and demographics.



What have we found?

1. Pacific children are born heavier than international reference groups, and remain so throughout their lifespan.

At birth the average PIFS child weighed 3.67 kg; with a weight z-score of 0.61 units significantly higher ($p < 0.001$) than the WHO standard. At 2 years and 4 years, average z-scores for weight and BMI were significantly greater than the reference group (mean z-scores for weight +1.06 and +1.69, for BMI +1.70 and +1.97 respectively, $P < 0.001$). Over 4 years, the daily weight gain was 11.2 g day⁻¹ compared with 8.9 g day⁻¹ for the WHO reference child. Using international BMI thresholds,⁴⁸ at 4 years, 60% of girls and 60% of boys in the PIFS could be defined as overweight or obese. They were on average 4% taller and 28% heavier than the average healthy 4 years old children, as defined by WHO.⁴⁹

Percentage body fat average for girls was 16% and boys 17%. At 6 years of age the rates of overweight and obesity were 31% and 29%, respectively, for boys and 32% and 25%, respectively, for girls. Children participating in the physical activity study at 6 years of age, on average, exhibited %BF z-scores of 1.75 standard deviations above the CDC growth reference child (range -0.60 to 3.14 standard deviations). Using BMI classifications, high levels of overweight and obesity were also found in this subsample of PIFS boys and girls (62% and 58%, respectively).

2. Maternal and early life factors are related to children's weight status.

Children of mothers who exclusively breastfed to the age of 6 weeks and did not smoke ($n=287$) versus the comparison group ($n=372$) weighed less and were slightly shorter at 2 years and 4 years of age. Mothers who smoked during pregnancy gave birth to smaller babies but these babies gained weight over four years faster than the children of the mothers who did not smoke. Children who were not exclusively breastfed showed a faster increase in weight in the first 4 years of life, and a faster increase in height between 2-4 years, compared with exclusively breastfed children, independent of prenatal and postnatal factors. Interestingly, at 6 years of age there was no measurable effect on children's body weight of breastfeeding or mothers not smoking during pregnancy. High birth weights in the children partially explained the higher rate of weight increase compared with reference groups. High levels of overweight, obesity, and high waist circumference values were found in mothers when the children were aged 6 years (31%, 68%, and 77%, respectively). After accounting for all other factors, watching television almost every day, and having a mother with a high waist circumference were associated with child body fatness when the children were aged 6 years; while none of the objective physical activity measures were associated with children's BMI z-scores, nor was maternal BMI.⁶⁰ Incidentally, maternal BMI was also not associated with child BMI in the examination of parental perceptions of their child's body size.⁵¹ Findings also showed that maternal physical activity was associated with that of their child.⁵⁹

3. Food insecurity is high in Pacific families and financial barriers to eating healthily exist.

When the children were aged 6 weeks, mothers reported that due to lack of money; food "sometimes" ran out in 40% and "often" ran out in 4% of households, and the variety of food was "sometimes" and "often" limited in 35% and 5% of households respectively. When the variety of food was limited by lack of money the foods that were still bought included bread (97%), milk (95%), meat and chicken (91%).



Alcohol (1%) and soft drinks (11%) were the least often bought. When examining affordability of foods consumed, rice, bread and fatty meats provided the most calories per dollar and fruit and vegetables the least.⁴³

4. Frequently consumed foods and relationships to growth at four years.

When the children were aged 4 years, mothers reported that the 12 foods most frequently consumed by their child included sources of carbohydrate; i.e., bread (80% white), breakfast cereal, banana, rice and noodles; dairy foods in the form of milk (80% standard) and yoghurt; fruits (predominantly oranges and mandarins, apples and pears); and protein (chicken, eggs). Traditional Pacific Island foods such as taro, cassava, corned beef, fish and green bananas were consumed by the 4 years old children on average only once a week. At 4 years higher consumption of protein foods was positively associated with weight, BMI, and weight gain (0 to 4 years), while frequency of foods high in fat was negatively correlated with these variables, in addition to %BF. Dairy consumption showed a positive correlation with body %BF and BMI.⁴⁵

5. Sedentary behaviour is high, and vigorous activity levels low, in Pacific children and their mothers.

Children engaged in high levels of sedentary behaviour (on average, 75% of accelerometer wear time), with moderate-to-vigorous physical activity levels ranging from 2-54% of measured time (mean of 25%), virtually no vigorous activity was measured (mean 0.4% of time), and there was little variance in the physical activity rates. Interestingly, almost all the days included in analyses showed the accumulation of at least 60 minutes of moderate-to-vigorous physical activity, the level recommended for optimal health outcomes in children. Mothers accumulated substantially less moderate-to-vigorous physical activity, with a mean of 15% of measured time (range 0-54%). After accounting for all other potential factors, associates of children's levels of moderate-to-vigorous activity were: male sex, weather (low rainfall, high sun hours), and maternal levels of moderate-to-vigorous activity.⁵⁹

6. The majority of parents were unconcerned about the future overweight status of their child.

At both 4 and 6 years of age, approximately two thirds (62% and 69%, respectively) of parents surveyed were unconcerned about the future weight status of their child. The proportion of parents who were concerned was related to the child weight status. For example, when the children were aged 6 years, 20%, 28%, and 51% of parents of normal weight, overweight, and obese children were concerned about their child's weight status, respectively (trend test, $p < 0.001$). Ethnicity and parity were significantly related to parental concern ($p < 0.001$). On average, Tongan parents were more concerned than respondents of other ethnicities, and parents with more children in the family were less concerned than respondents with fewer children.

What can we conclude from this research?

In the context of obesity-related diseases there are critical periods where opportunity may arise to influence downstream outcomes, either adversely or advantageously. Broadly these include prenatal, antenatal, postnatal/early infancy, early childhood, late childhood, adolescence, and adulthood. A key strength of the PIFS is that information has been collected from children and their families longitudinally since birth. Continuation of this study as the children progress through adolescence and into adulthood will enable us to



gain an in-depth, life course perspective of protective and risk factors for Pacific health and wellbeing. The aim of the current paper was to collate and summarise research conducted within the PIFS that considered physical activity, nutrition, or body size in the participating children. Five investigations have been reported here, that have identified key issues that can help to inform policy and practice for health promotion in Pacific people.

In keeping with prior studies, we have observed high levels of overweight and obesity in Pacific mothers, even after using ethnic-specific threshold values that are higher than those used for general populations.²⁵ Ethnic-specific threshold values account for the ethnic differences found in disease risk for a given body size.^{54,61-63} Likewise, we have found increased body size and a greater rate of weight gain across the lifespan in children participating in the PIFS than in general populations across all studies.

Maternal and early life factors play an important role in determining children's body size outcomes. Maternal non-smoking during pregnancy and exclusive breastfeeding to 6 weeks of age may protect children from increased body fatness in early life. While this relationship was not found at 6 years of age, there is substantial evidence for tracking of body size from early childhood to later life.⁶⁴⁻⁶⁶ Moreover, the numerous other health benefits of breastfeeding⁶⁷ and abstaining from smoking^{68,69} still make these important behaviours to promote to our Pacific mothers. As mothers are role models and "gatekeepers" to their child's nutrition and physical activity behaviours, improving health behaviours and outcomes in mothers will likely have a beneficial effect on their children, as evidenced in the links found between maternal and child physical activity and body size. While strategies that promote increasing physical activity and improving nutrition behaviours are important, effective solutions are likely to be more complex. For example, the generally low concern for their children's future weight status reported by mothers could be indicative of other stressors (e.g., health, economic, social) taking precedence in Pacific families. Similarly, an investigation of physical activity barriers, incentives, and perceptions in Pacific mothers revealed that physical activity was generally not an issue of importance for them.⁷⁰ Evidence from the New Zealand arm of the Obesity Prevention in Communities project showed that poverty-related factors were fundamentally linked to health promoting behaviours in Pacific communities.⁷¹ These findings underline the importance of empowering families with knowledge about the benefits of maintaining a healthy weight throughout the lifespan alongside culturally appropriate strategies that concurrently prioritise reducing social and economic inequalities.

For policy makers, it is important to recognise that rising obesity rates in Pacific Island families in New Zealand may lie, at least in part, in the selection of relatively inexpensive calorie-dense foods that are convenient and taste good in an effort to save money. Money is a fundamental influencing factor in food choices and assisting families with financial constraints to buy more nutritious foods for their money is recommended. The current 9-day Certificate in Pacific Nutrition offered in partnership by the National Heart Foundation (Pacific Heartbeat) and AUT University is one strategy, where Pacific community workers and those who work with Pacific learn about how to train, advise, and support others in making healthier food choices. The practical, hands-on course includes budgeting – for example being able to feed a family of six according to the food and nutrition guidelines for \$25 a day.⁷²

The built environment and availability of foods in the local neighbourhood are also important factors affecting food security,⁷³ and it is now well established that the built environment can have a significant influence on both physical activity and weight status.⁷⁴ The critical protective and adverse factors for overweight and obesity are essentially environmental, but ethnic and cultural influences are an integral part of the



environment.⁷⁵ The development of health promoting environments, alongside appropriate zoning policies, is thus likely to have a sustained effect on numerous health outcomes, while helping to address overriding contributing factors to social inequity (e.g., accessibility to gambling venues⁷⁶ and high cost credit⁷⁷).

Associates of children's moderate-to-vigorous physical activity were as expected, and suggest that interventions aimed at increasing this behaviour would benefit from involving mothers, promoting activity in females, and developing strategies for inclement weather. Associations between physical activity and body size however were in contrast with what might be expected in general populations, and support the self-reported data found previously for children.⁷⁸ We observed a high level of participation in sedentary behaviour in the study members, including television watching. In general populations, sedentary behaviour has been shown to have separate and independent negative effects on health outcomes, independent of physical activity levels.^{79,80} Benefits of physical activity and reducing sedentary time cannot be ignored; simply because a relationship was not found, it would be irresponsible to suggest at a public health level that these behaviours are not important. This may also be an issue of measurement; while we utilised objective and very sensitive measures of physical activity, we did not consider the accumulation of "bouts" of activity. It may be that optimal levels of physical activity for this population (and others) may be in the form of sustained participation in physical activity, rather than short intermittent bouts of moderate-to-vigorous physical activity. It is also plausible that the clustering of risk factors made it difficult to determine true associations. For example, watching television every day was associated with increased body size in children. While this is indicative of higher levels of sedentary behaviour in these children, it may also point to increased snacking behaviours and the consumption of unhealthy foods.⁸¹

Given the physiological differences between Pacific and non-Pacific groups,^{63,82} it is also possible that a differential dose-response exists between activity and body size in these groups. It is possible that more physical activity is required, at least initially, to combat the extremely high prevalence of obesity, or that particular dimensions of physical activity (e.g., sedentary behaviour) should be prioritized. Previous research has shown that self reported leisure time exercise levels of 30 minutes a day (or 210 minutes weekly) was associated with body size in European adults, but this relationship did not hold true for their Pacific counterparts.⁷ It was suggested that the impact of poor nutrition by Pacific participants overwhelms any protective effect that physical activity may provide in promoting a healthy body weight. The World Health Organization has developed physical activity guidelines for healthy Pacific adults (aged 18-65 with no contraindication to physical activity)⁸³, as follows: 1) If you are not physically active (moving much), it's not too late to START NOW! Do regular physical activity and reduce sedentary activities; 2) Be active every day in as many ways as you can, your way; 3) Do at least 30 minutes of moderate-intensity physical activity on five or more days each week; and 4) If you can, enjoy some regular vigorous-intensity activity for extra health and fitness benefits. It is possible that this level of activity is not actually sufficient for optimal health in Pacific peoples; indeed WHO acknowledge this and have developed the guidelines with the aim of encouraging small and achievable increases in physical activity in the most sedentary members of the Pacific population as a starting point for improving health and wellbeing in this community.

In summary, the influence of economic, social, and environmental features cannot be ignored in determining health promoting behaviours and outcomes in any population. The influence of nutrition and activity are not able to be disentangled: food is the fuel for all function and activity; structure and function are determined by the molecules that are eaten; but these simple biological principles are further shaped by behaviour and environment.⁸⁴ Without further research that encompasses objective measures of both physical activity



and nutrition behaviours within a socio-ecological framework (particularly considering socio-economic issues), it is difficult to determine exactly what the dose-response relationship for nutrition, physical activity, sedentary behaviours, and a healthy weight might be. Taken together, the results of this research suggest that a multifarious approach is required, targeting nutrition, economic, environmental, and physical activity interventions, in a culturally appropriate manner. Future research opportunities include conducting research to track objectively assessed health risk factors, including biomarkers for cardiovascular disease, diabetes, and obesity. At a macro level the investigation of the influences of changes in policy and environments aimed to reduce inequalities may have the most favourable long term impact on the health of future generations of Pacific people.^{85,86}

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