TARGETING THE TYPE 2 DIABETES EPIDEMIC IN POLYNESIA: HISTORICAL PERSPECTIVE AND RATIONALE FOR EXERCISE INTERVENTION TRIALS

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The Polynesian people of New Zealand are particularly vulnerable to type 2 diabetes mellitus (T2DM) and related comorbidities, including obesity and cardiovascular disease. T2DM could potentially be managed and abated with appropriate and targeted exercise prescriptions; however, the uptake of such interventions by this cohort remains low. The purpose of this article is to present a rationale for the investigation of targeted exercise prescriptions for the management and potential remission of T2DM in Polynesian people. The diabetes epidemic will be contextualized by contrasting historical observations of health and physical fitness with current trends and statistics related to significant T2DM risk factors (ie, obesity and inactivity). Longitudinal trials that have prescribed lifestyle-related and exercise interventions in this cohort will be critically reviewed, and novel research avenues will be proposed. Studies are currently required to investigate many critically important hypotheses in this cohort. The outcomes of such studies may facilitate the investigation of exercise prescriptions in other indigenous populations, including indigenous Australians, Americans and Africans, who also suffer a severe burden of T2DM. (*Ethn Dis.* 2012; 22(2):123–128)

Key Words: Aerobic Training, Resistance Training, Glycemic Control, Ethnic Population, Morbid Obesity, Diabetes

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INTRODUCTION

Polynesia is a culturally distinct region of Oceania, consisting of over one thousand islands in the central and southern Pacific. New Zealand, the largest island nation within Polynesia, provides a clear example of the health disparities that exist between the indigenous and nonindigenous people of this region.[1]

According to a recent national health survey,[2] Polynesian adults (ie, Maori and Pacific Islands people) have three times the prevalence of type 2 diabetes mellitus (T2DM) compared to the total population. By 2020, an estimated 18% of Polynesian people will be diagnosed with T2DM as compared to only 4% of New Zealanders of European origin.[3] These disparities have been attributed to extreme and unprecedented levels of obesity in the Polynesian people, influenced by environmental, sociocultural, biological and genetic factors.[4] Consequently, Polynesian people also suffer from a higher burden of cardiovascular disease,[5–7] which has contributed to marked and expanding inequalities in life expectancy.[8]

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Targeted exercise prescriptions could mitigate the diabetes epidemic in the Polynesian population of New Zealand. A wealth of empirical evidence has shown that prescribed exercise regimens, involving aerobic training, resistance training or a combination thereof, can improve diabetes and cardiovascular disease risk factors.[9–11] For example, many randomized controlled trials have noted that exercise training can improve glycosylated hemoglobin (HbA_{1c}) and additional pertinent clinical markers in patients with T2DM. Accordingly, exercise is currently advocated for the management and potential remission of T2DM.[12] Interestingly, however, the majority of trials used to formulate current position stands[12] have involved primarily Caucasian participants, or the ethnicity of the sample was not reported. This is notable given that certain cohorts, particularly indigenous people, are severely and disproportionately affected.[1,13] Limited investigation of the Polynesian diabetes population per se, may be contributing to limited uptake of exercise treatment by this cohort, thus contributing to current disease trends.[14]

The purpose of this article is to present a rationale for the investigation of targeted exercise prescriptions for the management and potential remission of T2DM in Polynesian people. The diabetes epidemic in this cohort will be contextualized by contrasting historical observations of health and physical fitness with current trends and statistics related to significant risk factors (ie, obesity and inactivity). Longitudinal trials that have prescribed active lifestyle and exercise interventions will be critically reviewed, and novel research avenues will be proposed.

HISTORICAL ACCOUNTS OF HEALTH, PHYSICAL ACTIVITY AND FITNESS

The westernization of Polynesian culture and the resultant health impairments are relatively recent and do not reflect the natural historical state of the Polynesian people. Investigations and observational reports have consistently shown that diabetes was virtually nonexistent in Polynesian communities maintaining traditional lifestyle and cultural practices.[14] Notably, such reports provide evidence of extremely high levels of physical activity and fitness.[15–17]

Centuries ago, French explorer Louis de Bougainville, struck by the lean and muscular bodies of the Polynesian people of Tahiti, commented, "I never saw men better made. I thought I was transported into the Garden of Eden."[15] Other explorers such as Cook, Magellan, and Quirós also marvelled at the "tall, muscular, and well-proportioned people" of the South Pacific.[15]

The seminal work of John Macmillan Brown published in 1907[16] highlights the origins of Polynesian people, providing evidence of migration patterns throughout Indonesia, Asia, and eventually to the South Pacific Islands. A defined pattern of habitual, daily physical activity emerges within the dialogue of Maori culture, customs, arts, war, hunting, gathering, agriculture, and fishing habits.[16] Brown provides references to the construction of canoes manually carved out from entire trees, and epic canoe voyages from other islands to New Zealand.[16] Descriptions of war rituals refer to *kapa haka*, the traditional Maori song and dance.

In 1939, Weston Price[17] commented on the "splendid physiques" and "great physical endurance" of the few Maori men and women who, up to that point in history, remained uninfluenced by westernization. Price noted that, "Few races have developed calisthenics and systematic physical exercise to so high a point as the Maori." Song and dance are performed by all until "the entire village is swaying in unison to the same tempo… with the result that these people maintain excellent figures to old age."[17] Price also learned that it was historically common for these groups "to make journeys of one to two thousand miles in crafts propelled by man power and wind."

According to Price, "The breakdown of these people comes when they depart from their native foods (eg, fresh fruits and vegetables, meats, fish and tubers) to the foods introduced through colonization, consisting largely of white flour, sweetened goods, syrup and canned goods."[17] The transition in health status, largely as a consequence of colonization, was reflected in increased levels of tooth decay, changes in physical features, and physical degeneration. Populations also declined in numbers, possibly as a consequence of lowered immunity to communicable diseases.[17] Price did not specifically comment on cases of obesity and diabetes during his period of study in Polynesia (ie, the 1930's). Rather, the disease epidemics today may represent the long-term effects of colonization. Price studied similar effects in other indigenous populations impacted by colonization.[17]

CURRENT OBESITY TRENDS

Obesity is a significant risk factor for T2DM.[4] The incidence of obesity is particularly high and continues to increase in the Polynesian people of New Zealand.[4,18,19] In a 2001 study of 534 South Auckland adults, obesity was present in 63% of Maori and 69% of Pacific Islands people vs only 26% of New Zealand Europeans.[4]

The obesity epidemic is also disproportionately affecting Polynesian children. Turnbull et al[18] determined that obesity was significantly higher among children of Pacific Islands descent (overweight=35.0%; obese=15.0%) and Maori descent (overweight=24.7%; obese=15.3%) vs those of European descent (overweight=18.2%; obese=5.7%). The authors identified "modern westernization," including excess television viewing, computer use, and video game play as the primary causative factor.[18] Tyrell et al[19] have corroborated these interethnic disparities in obesity among children.

Trends in childhood obesity are contributing to the early diagnoses of T2DM and related complications in Polynesian teenagers and young adults.[20,21] In a study that included 28 young (<30 years) Maori participants with T2DM, McGrath et al[20] reported that the average age of diagnosis was just 19.1 years. Of the young adults enrolled, 86% were categorically obese and 62% suffered from renal complications as a consequence of diabetes.

A comprehensive understanding of mechanisms responsible for higher rates of obesity in Polynesian people remains to be elucidated. Researchers contend that a thrifty genotype and/or phenotype, an evolved propensity to more efficiently store fat (ie, triglyceride) as an energy source, may be implicated. This selective evolutionary adaptation for efficient fat storage might have historically afforded protection against famine and the harsh climatic conditions of the South Pacific.[22] However, in the modern context of food overabundance and physical inactivity, this previously protective physiological mechanism has become a health liability. Clearly, environmental factors are implicated; the incidence of obesity and related comorbidities has increased sharply since colonization and concomitant shifts in diet and physical activity.[23]

CURRENT PHYSICAL ACTIVITY TRENDS

Chronic inactivity is an independent risk factor for a range of hypokinetic diseases such as obesity, diabetes, and cardiovascular disease. The updated

American College of Sports Medicine and American Heart Association guidelines for physical activity and health recommend a minimum of 30 minutes of accumulated moderate-intensity physical activity at least five times per week, or 20 minutes of vigorous activity at least 3 times per week to maintain or enhance health status.[24] A recent New Zealand survey of 4443 adults aged ≥16 reported that 53.5% of Maori, 52.6% of Pacific Islands people, and 48.9% of New Zealand Europeans met these guidelines.[25] Maori and Pacific Islands people also reported similar or higher participation rates in organised sports vs other ethnic groups.[25] However, these data were based on self-report and could therefore be unreliable.

A study in the United States objectively measuring physical activity levels of 6329 adults via accelerometer found that less than 5% of participants achieved 30 minutes of activity per day.[26] Another study of 1114 adults found that in participants who met the recommended guidelines, only 1% accumulated the recommended 30 minutes in bouts of at least 10 minutes.[27] Moreover, it has been suggested that those who meet the daily requirements but were sedentary for the remainder of the day (ie, during work hours) may actually negate the benefits of physical activity and remain at risk for various chronic diseases. For example, in a study of 4064 Australian adults who performed 150 minutes per week of physical activity, a significant and directly proportional association was observed between television viewing time and several important metabolic risk factors, including waist circumference, systolic blood pressure, fasting 2-hour plasma glucose, triglycerides, and high-density lipoprotein cholesterol.[28]

Additional, New Zealand-based research is required using objective measures (ie, accelerometers, inclinometers, global positioning system (GPS) technology) to quantify physical activity levels relative to diabetes and cardiovascular risk. This would provide a more accurate representation of inactivity-linked impairments across the general population, including Maori and Pacific Islands people, and allow for greater understanding of ethnic-specific disparities.

The outcomes of the recent physical activity survey in New Zealand[25] are interesting in light of current disease trends and statistics.[2] If Polynesian people are active to an equal or greater extent than New Zealand Europeans,[25] then a comparatively lower incidence of obesity and associated comorbidities might be expected. However, an alternate hypothesis could be that physical activity guidelines[24] may be insufficient to maintain or enhance health in this cohort given their historical propensity to habitually high levels of physical activity.[15–17]

LIFESTYLE INTERVENTION TRIALS

Prospective investigations have demonstrated that intensive lifestyle interventions that promote physical activity and fat loss can prevent T2DM and metabolic syndrome.[29,30] To date, three lifestyle intervention trials conducted in obese, nondiabetic New Zealand Polynesian participants[31–33] may offer useful information to guide the development of appropriate exercise interventions for this specific ethnic population.

McAuley et al[32] conducted an uncontrolled pilot study in a cohort of 31 obese Maori men and women. All participants received a 4-month lifestyle intervention program consisting of individualized dietary advice, cooking classes, general exercise recommendations, and four supervised exercise sessions. Insulin sensitivity, measured via euglycaemic insulin clamp significantly improved in the cohort ($P=.03$). The participants also experienced reductions in body mass index (−1.1 kg/m^2), total (−2.0 kg) and truncal fat mass (−1.1 kg), waist circumference (−7 cm), and systolic blood pressure (−7 mm Hg) (all $P<.04$).[32]

Simmons et al[33] conducted a two-year, prospective, non-randomised controlled lifestyle intervention trial that included data from of an earlier pilot study.[34] Five-hundred and sixteen Samoan and Tongan church congregants received diabetes education, cooking demonstrations, and light aerobic exercise sessions with the aim of reducing diabetes risk factors. The exercise sessions were church-based and included cultural movements such as traditional forms of dance. Simmons et al[33] reported a significant increase in exercise participation from baseline (+22%), stabilisation of weight gain (no change), and a reduction in waist circumference (−4 cm) in Samoan participants receiving 24 months of the intervention compared to a nonintervention control group (all $P\leq.05$). In Tongan congregants, exercise participation, body weight, and waist circumference remained unchanged after two years and was attributed to lower participation rates and perceived usefulness of the intervention.[33] Diabetes knowledge, assessed by the diabetes knowledge and behavior questionnaire,[35] increased significantly in both Samoan (+46%) and Tongan intervention groups (+19%) compared to their respective control groups ($P\leq.02$), but more so in the Samoan church group who experienced greater health benefits.[33]

In a one-year, non-randomised controlled trial investigating the effect of a weight management intervention (ie, exercise program plus nutrition education) in 471 obese Samoan church members, Bell et al[31] reported a significant increase in the number of participants who were categorised as vigorously active (+10%; $P=.007$), a reduction in body weight (−.4 kg; $P=.04$), and a trend toward reduction in systolic blood pressure (−10 mm Hg; $P=.09$) in the experimental group. Although the absolute change in body weight was small (.4 ± .3 kg) the authors noted that even small reductions or stabilisation in weight in this high-risk population may substantially reduce the risk of developing hypokinetic diseases such as T2DM.

EXERCISE INTERVENTION TRIALS

To our knowledge, only one trial to date has evaluated the efficacy of prescribed exercise training in a cohort of Polynesian adults diagnosed with T2DM and visceral obesity.[36] Eighteen participants, including 13 women and 5 men, with a duration of known diabetes of .5 to 13 years completed the study. The total cohort had a mean body weight of 122.7 ± 29.6 kg and mean waist circumference of 128.7 ± 18.7 cm. Mean body mass index (BMI) indicated class III (morbid) obesity (43.8 ± 9.5 kg/m^2). All participants met the Adult Treatment Panel III definition for metabolic syndrome.[37] Based on mean BMI, this was the most obese cohort studied in the exercise in T2DM literature to date.

Participants were randomized to either a resistance training group or an aerobic training group that both exercised thrice-weekly for 16 weeks. The duration of each exercise session ranged from 40–60 min, increasing progressively over time. The exercise regimens were developed according to guidelines published by the American College of Sports Medicine.[12] The resistance training group performed two to three sets of eight major exercises using machine weights targeting all the major muscle groups of the body for 6–8 repetitions to neural fatigue, while the aerobic training performed exercise on a cycle ergometer at 65 to 85% of their heart rate reserve. The interventions were fully supervised by qualified exercise physiologists and the intensity of exercise was increased with fitness improvements in all participants.

Few endpoints, including HbA_{1c}, blood lipids, relevant cytokines (C-reactive protein and adiponectin), and anthropometric and hemodynamic indices, were modified as a result of aerobic or resistance training. While aerobic training significantly reduced systolic and diastolic blood pressure, HbA_{1c} remained elevated in both groups. No other changes were detected within or between groups. Importantly, however, despite the extreme levels of chronic disease in this cohort, only one adverse event (ie, an acute episode of syncope) was reported for the entire duration of the trial, suggesting that the interventions were both safe and feasible, and indicating a need for further research of prescribed exercise interventions.

DISCUSSION

A wealth of empirical evidence suggests that prescribed exercise training can elicit significant and clinically important improvements in chronic glucoregulation and many other pertinent health outcomes in patients with T2DM.[9–11] Notably, none of the trials used to generate current positions statements for exercise in diabetes[12] have enrolled exclusively indigenous participants. This is significant as many indigenous populations including Polynesians are severely affected by T2DM.[1]

The lifestyle intervention trials reviewed have yielded many positive findings.[31–34,38] However, a number of limitations related to the reporting of specific physical activity or exercise prescriptions must be considered. First, exercise prescriptions and compliance data were not clearly described. In the church studies, the participants engaged in sitting exercises, low-impact aerobics, walking, and sports[34] or walking groups and aerobics classes,[31] but no specific information regarding exercise frequency, intensity, or duration was provided. This introduces problems for replication of these studies, the application and practical utility of findings, and the development of exercise prescription guidelines to minimise diabetes risk and enhance health status in this cohort.

McAuley et al[32,38] prescribed the 1990 American College of Sports Medicine guidelines for cardiovascular exercise[39] and provided heart rate monitoring instructions to their participants, but did not mention levels of attendance or compliance to these guidelines. There were also inconsistencies in the testing methods employed by the researchers and the reported results. For example, the authors stated that participants performed a one-mile walk test to assess aerobic fitness, but the published data were based on a modified Bruce treadmill protocol.[32,38] Such limitations introduce difficulty in interpreting the data.[31,33,34]

Second, randomisation of participants to a nonexercise control group has proven difficult in the lifestyle intervention trials. For example, McAuley et al[32] intended to carry out a randomised controlled trial, but this was not feasible due to the close proximity and sharing of information between participants potentially randomised to different groups. Further, a control group was deemed unethical since participants stated they knew they were at high risk for developing diabetes and should therefore be afforded a potentially beneficial treatment.[32] Bell et al[31] and Simmons et al[34] recruited large numbers of church congregants which, by nature of the communal setting, made it difficult to conceal the intervention from the control groups. In fact, one control group initiated their own exercise program because they were upset about not receiving the intervention.[34] Moreover, ministers and church members sometimes participated in opposing churches' meetings, which may have compromised the integrity of the control due to sharing of study-related information and experiences.[31]

Lastly, the combination of treatment modalities provided (ie, diet and exercise education, exercise classes) makes it difficult to determine the extent to which these results could be attributed solely to the exercise component. This does not invalidate the findings of these holistic interventions,[31–34] but instead provides impetus for further research, which may eventually elucidate the isolated effect of a variety of exercise prescriptions on important health outcomes. Future exercise trials addressing these limitations are necessary and important for increasing advocacy for exercise as a therapeutic modality for Maori and Pacific Islands people.

The recent trial by Sukala et al[36] enrolled a Polynesian cohort afflicted with T2DM and visceral obesity and randomized participants into two prescribed exercise training groups (aerobic and resistance) for 16 weeks. Although many of the clinical endpoints did not improve significantly, the salient findings demonstrated safety and feasibility and provide a rationale for the continued investigation of exercise interventions in this population. Previous studies in other ethnic populations have shown that thrice-weekly aerobic or resistance training for ≤16 weeks is sufficient to induce significant and clinically meaningful adaptations.[40–42] Sukala et al[36] attributed the lack of holistic adaptation to the extreme level of obesity in their cohort and concluded that more frequent and longer duration training would be required to elicit significant improvements in these diabetes and obesity-related markers. In support of this, the post-hoc analyses using pooled data indicated that higher adherence to training significantly reduced waist circumference ($P<.001$) and tended to reduce body weight and fasting insulin vs lower adherence.[36] Higher adherence was also associated with reduced CRP, and hence reduced risk of cardiovascular morbidity and mortality.[43]

Obesity is a significant and highly prevalent risk factor for diabetes in the Polynesian community in New Zealand.[4,18,19] The reduction of whole body adiposity (including visceral and intramyocellular fat deposits) is required to enhance markers of glucoregulation in obese patients.[36] Hence, greater frequency and longer duration of training would likely induce more favorable changes in fat and fat-free mass, and thus more favorably improve parameters such as HbA1c. Further, Sigal et al[44] have shown that comprehensive exercise interventions, combining both aerobic and resistance training, are more effective for diabetes control than either of these modalities prescribed in isolation, as these interventions may more favorably enhance shifts in body composition (ie, increase fat-free mass and reduce fat mass). Such interventions remain to be investigated in Polynesian people.

Historical accounts suggest that Polynesian people were accustomed to extreme levels of physical activity for daily living, food procurement, dance and rituals and inter-island travel, among other reasons.[17] These populations have also been historically revered for their high levels of physical endurance and fitness.[17] Due to these selective factors and microevolution, it could be hypothesized that Polynesian people generally require and are able to tolerate greater doses of physical activity or exercise training vs other populations, including Caucasians. Empirical investigations have indeed demonstrated that physiological disparities in diabetes-related risk factors exist between ethnic groups, including between Caucasians and Polynesian people,[45] giving rise to the possibility that the physiological response to exercise might also vary according to ethnicity. Trials comparing exercise dosages across ethnic groups are required to investigate such hypotheses.

Future studies must direct greater attention toward fostering exercise adherence in this cohort by making interventions more practical. According to Sukala et al,[36] work and family obligations were cited as common reasons for missed sessions. Active interventions integrated into work hours and involving family members could potentially increase exercise adherence and hence contribute to greater adaptation.

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Foliaki and Pearce[14] have noted that behavior modification in Polynesian people is more likely to succeed with the involvement and support of family and community members. Therefore, group-type and community-based interventions that provide a sufficient exercise overload stimulus may be indicated. Traditional forms of exercise (eg, paddling and dance) may be most accepted and desirable. Such an approach could involve the integration of exercise prescriptions within the marae or church settings. Additional trials are required to pursue such research questions.

In summary, exercise training may help mitigate the diabetes epidemic in the Polynesian community of New Zealand. However, studies are required to investigate many critically important hypotheses. The outcomes of such studies may facilitate the investigation of exercise prescriptions in other indigenous populations, including indigenous Australians, Americans and Africans, who also suffer a severe burden of T2DM.

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Manuscript draft: Sukala, Page, Cheema
Acquisition of funding: Page
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