Physical Activity and Obesity Research in the Asia-Pacific: A Review

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Abstract
Obesity is a global health concern and has a great impact on countries in the Asia-Pacific region. Physical inactivity is a major risk factor for obesity, but physical activity levels are declining in much of this region. Increasing physical activity is a priority in many countries. Considerable research has been conducted on physical activity related to obesity in Western countries, but populations in the Asia-Pacific region differ in physical, psychological, social, and cultural ways that warrant local and regional research. The authors reviewed research conducted in the Asia-Pacific region that examined either the impact of physical activity interventions on obesity-related outcomes or the effect of behavior-change interventions on physical activity participation. The number of studies found was limited, and their samples and methods varied too much to draw conclusions. The authors recommend further research in the Asia-Pacific region using systematic protocols to permit sound conclusions to be drawn and promote informed action at local levels.

Keywords
obesity, overweight, physical activity, exercise, interventions, behavior change

Introduction
The prevalence of overweight and obesity is increasing rapidly in many countries around the world, both in regions that are developed¹,² and those that are developing.³,⁴ Although the reasons for this are complex and vary across locations, the growth of urban living, including the availability of inexpensive, energy-dense foods and the mechanization of work and transport, is often associated with noteworthy increases in obesity.⁵ The World Health Organization (WHO) and researchers on obesity and health have described this trend as an epidemic because obesity has been shown to increase the risk of many debilitating and life-threatening noncommunicable diseases (NCDs).¹,⁶,⁷ The WHO, other international organizations with an interest in health and well-being, and national governments consider action to address the global obesity epidemic to

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be a priority.\textsuperscript{1,4} These organizations have identified turning the tide of increasing physical inactivity to be an important strategy because of the relative ease with which most people can include more physical activity (PA) in their lives. Research examining ways to manage obesity that focus on increasing PA and research evaluating PA intervention programs are well established in many Western countries, especially in North America and Europe.\textsuperscript{5-10}

The Asia-Pacific is a vast and highly populated region in which many countries reflect the highest levels of obesity in the world or the most rapid increases in obesity.\textsuperscript{5} The increase in obesity is seen in both rural and urban areas.\textsuperscript{11} The prevalence of obesity in some countries in this region is as high as that in Western nations such as the United Kingdom and the United States.\textsuperscript{12} At the same time, the diverse economic, social, and cultural practices in nations across this region as well as variations in biological and psychological factors raise concerns about the direct transfer of approaches developed in Western populations to address obesity among people in many countries in the Asia-Pacific region. For example, experts question application among various Asian or Pacific populations of the most widely used indicator of obesity, the body mass index (BMI). The BMI thresholds for overweight (>25 kg/m\textsuperscript{2}) and obesity (>30 kg/m\textsuperscript{2}) have been developed largely in Western contexts, where typical height and body composition differ from many Asian and Pacific populations. Given the rich variety of psychological, social, and cultural factors that make up lifestyles in different Asian and Pacific nations, it is dangerous to assume that PA-based approaches to the management of obesity that have been shown to be effective in research and program evaluation with North American or European samples will work equally well among people from Brunei, Mongolia, or Samoa, where the prevalence of obesity is high. Thus, it is important to consider research that has been conducted among appropriate populations in the Asia-Pacific region as the basis for the development and implementation of PA intervention programs among those populations.

This review examines research among people from the Asia-Pacific region that has addressed either (a) the effect of a PA program on outcomes associated with obesity or (b) techniques to increase PA among people who are obese. The aim of the review is to assess whether evidence from research that has used Asian Pacific samples provides consistent and substantial support for the efficacy of PA programs for the management of obesity and whether a body of research reliably demonstrates the effectiveness of interventions designed to increase PA among obese people from the Asia-Pacific region.

Method

A systematic search was performed in August 2011 using EBSCOhost databases, including Australia New Zealand Reference Centre, CINAHL, Health Source/Academic Edition, MEDLINE, Psychology and Behavioral Sciences Collection, PsycINFO and SPORTDiscus. The following combination of keywords was used: obesity or overweight AND physical activity or exercise AND intervention or review AND Asia Pacific. Intervention studies that used quantitative or qualitative approaches for obese participants were included. Searches were also conducted on Google Scholar. Titles and abstracts found through the search process were reviewed to identify articles that focused on research to enhance PA in overweight and obese people and the effects of PA on people who were overweight and obese. The reference lists of identified reports and articles were used to search for additional articles that met the criteria. Searches were limited to studies that were published in the English language from 2000 to 2011.

Results

In the literature searches using the methods described in the previous section of this review, we identified 16 studies conducted with samples from the Asia-Pacific region that examined the
impact of PA interventions on aspects of obesity. A further 3 studies examined the effect of interventions designed to increase PA among obese people from this region. The studies in both these categories were diverse in terms of characteristics of participants, intervention type, duration of intervention, and outcomes measured. The studies are listed in Table 1, which includes details of the samples, the measures, the interventions, and the main outcomes. This table underpins the description of the results in this section. Table 1 shows that most of the research examining the effects of PA on aspects of obesity and interventions to increase PA in overweight people has been recent.

**Characteristics of Participants**

Of the studies that examined the impact of PA, more than half (56%) were conducted in Australia (7) and New Zealand (2). The participants of one of the New Zealand studies were migrant Indian Asians. Of the studies, 2 were carried out in Korea, and 1 study each was conducted in China, Malaysia, Taiwan, Thailand, and Vietnam. There were no studies from the Pacific Islands. We found that 5 studies concentrated on children, 3 on youth, 6 on adults, and 2 on older adults. In 3 of these studies, all the participants were female, whereas in the other studies participants represented both genders. Studies examining ways to increase PA in Asia-Pacific populations included 1 study with children and 2 with adults.

Sample size in the impact studies varied from 4 in the case study of Brennan et al to 5126 in the school-based intervention undertaken by Sirikulchayanonta et al. The participants in several studies on children and youth also included parents: for example, studies by Brennan et al and O’Connor et al on the impact of PA and by Chotibang et al, which also included teachers, school administrators, cafeteria staff, and vendors in their intervention to increase PA. The participants in some studies on adults had health conditions in addition to obesity, including schizophrenia, osteoarthritis, and insulin resistance.

**Intervention Type**

The content of the intervention varied among studies. Four studies on the impact of PA used only PA. The other studies used multimodal interventions that typically combined PA with diet, nutrition, or behavior change strategies. One study aiming to increase PA included PA increase as the only outcome, whereas the other 2 also proposed to promote healthy eating or alter energy intake.

Of those studies that dealt with the impact of PA, 6 compared the intervention group with a control group. In one of the studies, obese women were compared with nonobese women; 3 studies had more than 1 intervention group. Dale et al and Wycherley et al had 2 intervention groups. In the study by Dale et al, the 2 interventions were described as a “modest lifestyle” intervention and an “intensive lifestyle” intervention. Wycherley et al introduced 2 interventions that went through a moderate energy-restricted diet either with or without aerobic exercise training. Okely et al used 3 intervention conditions—namely a parent-centered dietary program, a child-centered PA program, and a combination of diet and PA.

**Intervention Duration and Time to Follow-up**

The duration of the studies of the impact of PA on aspects of obesity and the intervention programs to increase PA also varied considerably, with programs lasting from 8 weeks to 9 months. Of the programs that examined the impact of increasing PA on obesity, 6 included a follow-up. In the study by Chang et al, the follow-up was at 12 months, 3 months after the supervised exercise ended, whereas in the study by Chen et al, follow-up started 2 weeks after the
### Table 1. Summary of Studies

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<tr>
<td>Impact of physical activity (PA) on outcomes related to obesity</td>
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<td><strong>Cliff et al (2007)</strong>&lt;sup&gt;8&lt;/sup&gt; Australia</td>
<td>To assess feasibility of a community-based PA motor development program (SHARK) among overweight and obese children</td>
<td>13 Overweight or obese children (64% female, 36% male; age 10.4 ± 1.2 years)</td>
<td>Anthropometric measurements, movement development, perceived competence, PA, and time taken to perform sit-to-stand transfer; assessments conducted at baseline (week 0), posttreatment (week 10) and 9-month follow-up (week 36)</td>
<td>10-Week PA after school program</td>
<td>At posttreatment and follow-up, there was significant (P &lt; .05) improvement in motor development, perceived athletic competence, and perceived global self-worth and decline in moderate and vigorous PA</td>
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<td><strong>Rush et al (2007)</strong>&lt;sup&gt;13&lt;/sup&gt; New Zealand</td>
<td>To investigate the effect of lifestyle modification in a cohort of older Asian Indian residents in New Zealand on abdominal obesity, insulin resistance, blood lipid profile, and blood pressure</td>
<td>41 Asian Indians (20 female and 21 male; age &gt; 50 years)</td>
<td>Anthropometric measurements, body composition, triglycerides, cholesterol, glucose, lipid, insulin, blood pressure, and number of steps taken</td>
<td>5-Month intervention that included education sessions to improve diet and encourage PA (group sessions on diet, PA, and lifestyle changes to reduce risk factors)</td>
<td>Significant decrease (P &lt; .006) in body weight, total and percentage body fat, waist girth, and abdominal fat in men; significant increase (P &lt; .002) in HDL levels and decrease in LDL and total cholesterol (TC)/HDL ratio in men and women; reduction in systolic and diastolic blood pressure was associated with an increase in HDL cholesterol in women (r = 0.63, P = .003, r = 0.48, P = .03)</td>
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<td><strong>Chang et al (2008)</strong>&lt;sup&gt;19&lt;/sup&gt; China</td>
<td>To investigate the effects of long-term supervised exercise-induced weight maintenance on metabolic risk factors and physical fitness in obese children in early puberty</td>
<td>49 Obese children and adolescents (12-14 years) were divided into 2 groups: exercise group (n = 25; age 12.6 ± 0.76 years) and control group (n = 24; age 12.2 ± 0.07 years)</td>
<td>Anthropometric measurements, fasting serum lipids, glucose, insulin, and a homeostatic model assessment for insulin resistance (HOMA-IR)</td>
<td>Two groups: exercise and control; both groups received health education once every 3 months for 12 months; participants in the exercise group received 9 months of exercise intervention</td>
<td>At the end of the intervention, the exercise group had significant reduction (P &lt; .05) in BMI; significant decrease (P &lt; .05) in triglyceride levels, HDL, fasting serum glucose, insulin level, and HOMA-IR; and increased (P &lt; .01) upper- and lower-limb strength, flexibility, and endurance. Three months after termination of intervention, BMI and waist circumference of the exercise group increased to higher than at the beginning of the study, and serum triglycerides, glucose, insulin, HOMA-IR level, prevalence of hypertriglyceridemia, and hyperglycemia returned to preintervention levels</td>
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<tr>
<td>Dale et al (2008) / New Zealand</td>
<td>To determine whether intensive education and support provided over 4 months produced sustained lifestyle changes and maintenance of weight loss</td>
<td>79 Normoglycemic, insulin-resistant adults (53 female and 26 male; age 30-68 years)</td>
<td>Anthropometric measurements, blood pressure, cholesterol, triglycerides, glucose, and insulin; Follow-up at 8, 12, and 24 months</td>
<td>Three groups: control, modest intervention, and intensive intervention; 4-month intervention where the modest and intensive intervention groups received detailed diet and exercise advice; modest and intensive refers to the extent to which participants were asked to change their diet and exercise patterns; control group participants were advised to continue their usual diet and exercise routine</td>
<td>Significant ($P &lt; .05$) weight loss in the intensive and modest groups and reduced waist circumference after the 4-month intervention; insulin sensitivity improved in the intensive intervention group At 2 years, combined intervention group had significantly lower ($P &lt; .05$) triglycerides compared with the control group</td>
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<td>O'Connor et al (2008) / Australia</td>
<td>To evaluate the Loozit community-based adolescent weight management program</td>
<td>22 Overweight/Obese adolescents (15 female and 5 male; age 13-16 years), but 2 girls did not complete posttest</td>
<td>Anthropometric measurements, blood pressure, cholesterol, triglycerides, insulin, glucose, self-esteem, dietary fat intake, PA, and sedentary behavior</td>
<td>Loozit weight management intervention: seven 75-minute group sessions weekly for 4 weeks and at 2, 4, and 5 months; sessions focused on healthy eating and increasing PA, decreasing sedentary activity, and increasing self-esteem</td>
<td>Significant improvements in waist circumference ($P &lt; .0001$), HDL ($P &lt; .05$), and self-perception scores for physical appearance and romantic appeal ($P &lt; .05$); no BMI changes. According to parents, their children chose healthier food and increased PA</td>
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<td>Wycherley et al (2008) / Australia</td>
<td>To determine whether the addition of aerobic exercise training to a moderate calorie-restricted diet had any effect on flow-mediated dilation (FMD) in overweight and obese patients with type 2 diabetes and whether any changes were associated with changes in oxidative stress and nitric oxide availability</td>
<td>29 Sedentary, overweight, or obese individuals with type 2 diabetes (age 52.4 ±1.4 years) were divided into 2 groups: diet and diet plus exercise</td>
<td>Anthropometric measurements, blood pressure, body composition, FMD, glyceryl trinitrate, peak oxygen consumption, glucose, glycated hemoglobin (HbA1c), insulin, cholesterol, triglycerides, total antioxidant status and malondialdehyde (MDA) levels, FMD, and urinary nitrate/nitrite</td>
<td>Two groups: diet intervention and diet plus exercise intervention; 12-week intervention; diet group consumed high-protein, energy-restricted diet; diet plus exercise group consumed high-protein, energy-restricted diet and walked/jogged 4 to 5 times per week; participants kept diary of each exercise session</td>
<td>Both groups showed significant reduction in body weight, body fat, and waist circumference ($P &lt; .001$); reduction in blood pressure, glycated hemoglobin, glucose, insulin resistance, lipids; and MDA; and increases in urinary nitrite/nitrate ($P &lt; .05$). No differences between groups.</td>
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<td>Brennan et al (2009)18/Australia</td>
<td>Report implementation of a cognitive behavioral lifestyle intervention for overweight and obese adolescents</td>
<td>4 Case studies (2 overweight/obese females and 2 overweight/obese males; age 12-15 years)</td>
<td>Anthropometric measurements, body composition, cardiovascular fitness, weighed food diary, accelerometer, PA self-report, self-esteem, depression, anxiety and stress, and eating attitudes</td>
<td>Intervention program (individual basis) consisted of treatment and maintenance phases; treatment phase made up of 9 weekly, 60-minute, face-to-face sessions and 15-minute phone call sessions; maintenance phase made up of two 60-minute clinic sessions and six 15-minute maintenance phone call sessions. Parents and adolescents attended sessions.</td>
<td>All participants improved in body composition, reduced energy intake, and improved quality of diet and psychosocial well-being</td>
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<td>Chen et al (2009)22/Taiwan</td>
<td>To evaluate effectiveness of a 10-week weight control program for outpatients taking atypical antipsychotics for treatment of schizophrenia or schizoaffective disorder</td>
<td>33 Patients (27 female and 6 male; age 31.9 ± 6.4 years) with schizophrenia and antipsychotic-related obesity</td>
<td>Anthropometric measurements, blood sugar level, cholesterol, triglycerides, quality of life, and mental health; weight recorded at baseline, week 4, week 8, week 10 (end of program), week 12, week 24, and week 48</td>
<td>10-Week multimodal weight control program “A Meaningful Day Program” (nutrition counseling, exercise, and behavioral interventions). Weight control consisted of 10 sessions of 90-minute group activities. Eight of the sessions included 45 minutes of aerobic exercise. Participants also did 45 minutes of aerobic exercise 3 times per week at home.</td>
<td>After the end of the program, there was a significant (P &lt; .05) weight loss for all participants; mean weight loss of 2.1 kg by the end of the intervention, 3.7 kg over 6 months, and 2.7 kg over 12 months. At the end of the program, participants had a significantly (P &lt; .05) lower level of triglycerides and significant improvement in quality of life and mental health</td>
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<td>Choi et al (2009)23/Korea</td>
<td>To examine the effect of exercise training on levels of lipocalin family protein (relation to obesity and metabolic syndrome), inflammatory markers and other cardiovascular risk factors in obese Korean women</td>
<td>30 Obese women (age 46.7 ± 7.5 years) and 15 nonobese women (age 49.4 ± 7.8 years)</td>
<td>Anthropometric measurements, blood pressure, triglycerides, cholesterol, aspartate aminotransferase, alanine aminotransferase, glucose, insulin, HOMA-IR, adipocyte fatty acid-binding protein (A-FABP), lipocalin, retinol-binding protein 4, high-sensitivity C-reactive protein, and interleukin-6</td>
<td>3-Month exercise program (45 minutes, 300 kcal/d); strength training (20 minutes, 100 kcal/d), 5 times/wk. Concentrations of lipocalin family proteins were compared between obese and nonobese women before and after the exercise program.</td>
<td>There was a significant reduction in weight, BMI, waist circumference, and serum A-FABP levels (P &lt; .001)</td>
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<tr>
<td>McGuigan et al (2009)</td>
<td>To determine the efficacy of an 8-week resistance training program on body composition in overweight and obese children</td>
<td>48 Obese or overweight children (26 girls and 22 boys; average age 9.7 years)</td>
<td>Anthropometric measurements, body composition, bone density, strength, power, muscular endurance, activity records, and nutritional intake</td>
<td>Resistance training program (3 times per week) for 8 weeks</td>
<td>Significant reduction in absolute percentage of body fat ($P = .003$), increase in lean body mass ($P = .07$), increase in one repetition maximum squat, number of push-ups, countermovement jump height, static jump height, and power</td>
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<td>Campbell et al (2010)</td>
<td>To compare the effects of 12-week intermittent, interval (INT) exercise program and diet with intermittent continuous (CON) aerobic exercise program and diet on cardiovascular fitness, body composition, resting metabolic rate, and blood lipids in obese population</td>
<td>26 Sedentary obese individuals (18-25 years)</td>
<td>Anthropometric measurements, blood pressure, resting metabolic rate, body composition, aerobic fitness, TC, triglycerides, HDL, LDL, VLDL, coronary risk ratio, exercise diary, exercise and food diary, and number of steps taken per day</td>
<td>Two groups: INT exercise program with diet and CON aerobic exercise program with diet; exercise for both groups included 15-minute walking for 5 days per week for 12 weeks. INT group exercised on a 2:1 minute ratio of low-intensity (40%-45% VO2peak) and high-intensity (70%-75% VO2peak) exercise, whereas the CON group exercised at between 50% and 55% VO2peak. Both groups were on a restricted diet</td>
<td>Both interventions had similar outcomes. Only the INT group had significant improvement ($P &lt; .05$) in VLDL</td>
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<td>Ha et al (2010)</td>
<td>To determine obesity-related eating and behavior problems in elderly Koreans and to determine whether Danhak exercise is appropriate for improving health problems in elderly overweight/obese individuals</td>
<td>120 Elderly adults (age 66.1 ± 4.7 years)</td>
<td>Anthropometric measurements, body composition, plasma triglycerides, TC, and HDL cholesterol</td>
<td>Two groups: intervention group and control group; intervention group had 6 months of Danhak exercise program, 5 days per week (5 minutes warm-up, 60 minutes main exercises, and 15 minutes final stretching)</td>
<td>Significant reduction ($P &lt; .05$) in body fat and waist-to-hip ratio, improvement in TC and HDL, and improved self-confidence, movement, stress relief, and depression</td>
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<td>Okley et al (2010)</td>
<td>To evaluate whether a child-centered PA program combined with a parent-</td>
<td>165 Overweight or obese children (age 5.5-9.9 years)</td>
<td>Anthropometric measurements, cholesterol, glucose, insulin, and blood pressure; outcome</td>
<td>Three intervention groups: parent-centered dietary modification program (Diet), child-centered PA</td>
<td>At 12 months, BMI reduced in all groups with Diet and Diet + Activity groups showing greater reduction than the PA group ($P &lt; .05$)</td>
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<tr>
<td>Sirikulchayanonta et al (2010)</td>
<td>To improve nutrition and PA among primary school children</td>
<td>5126 Primary school children (2407 girls and 2719 boys; age 6-12 years) from 4 public schools in Bangkok</td>
<td>Anthropometric measurements, nutritional status, dietary intake, and PA; evaluation done 8 months after launch of projects</td>
<td>2-Day training on child health promotion for teachers, seminars on obesity and health for parents and students, program content taught to students once a week for 16 weeks</td>
<td>Significant increase in aerobic exercise (P &lt; .001) and decrease in high-caloric dietary intake (P &lt; .001); obesity decreased from 19.3% to 16.8%</td>
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| Krasilshchikov et al (2011) | To determine the effect of a combined resistance and aerobic exercise program on early primary knee osteoarthritis on overweight and obese middle-aged and elderly women | 16 Sedentary overweight and obese women (50-64 years) with early-stage primary knee osteoarthritis | Anthropometric measurements, pain and physical function assessment, muscular strength and endurance assessment, cardiorespiratory endurance assessment | Two groups: intervention and control; intervention group had 8 weeks of progressive combined resistance and aerobic exercise (1 hour sessions, 3 times a week) | Significant (P < .05) improvements in pain and physical function score, knee extensor concentric peak torque at 120°/s and 180°/s, and 6-minute walking distance |

| Ngoc et al (2011) | To evaluate the effects of healthy diet and increasing PA promotion on prevention and treatment of obesity in primary school students | 2500 Students (age 6-10 years) in 2 primary schools (1 intervention school and 1 control school) | Anthropometric measurements, PA and diet habit, knowledge of nutrition (students, teachers, parents), and investigation of school lunch and food available in school canteen | Intervention was implemented in 1 school year and consisted of nutrition and physical education lectures, communication materials, provision of sport facilities, and playground markings | Reduction of obesity in the intervention school was 2 times that of the control school (8% and 3.9%); improved behavior in the intervention school in terms of better food choices, increased PA, and decreased PC use for leisure |

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### Interventions to change PA behavior

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<tr>
<td>Rowley et al (2000) Australia</td>
<td>To assess the sustainability and effectiveness of a community-directed program for primary and secondary prevention of obesity, diabetes, and cardiovascular disease in an Aboriginal community in north-west Western Australia</td>
<td>49 High-risk overweight and diabetic people</td>
<td>Anthropometric measurements, glucose, insulin, triglyceride, PA, and dietary habits; they were screened at 2 or more 6-month intervals over 24 months</td>
<td>Two groups: intervention and nonintervention; intervention included formal and informal education sessions, regular PA groups, and dietary changes; PA included hunting trips, sports, and walking (3-4 1-hour sessions per week)</td>
<td>Significant decrease in BMI for the whole cohort at 6 months ($P &lt; .001$), although decrease in the intervention group was larger ($P &lt; .05$); fasting plasma glucose concentration decreased across groups over 24 months</td>
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| Chotibang et al (2009) Thailand | To develop a family and school collaborative program for promoting healthy eating and PA for school-aged children in Chiang Mai, Thailand | 1 Primary school in urban Chiang Mai; 3 groups involved: (1) core working group (2) stakeholders for needs assessment (3) team members for implementation of programme | Interviews, participant observation, workshops with stakeholders, discussions, monitoring and reflections of research progress, environmental assessments of school and surrounding community, and height and weight measurements of school children | Implemented the Family and School Collaborative (FASC) program, which included developing school policies to promote healthy diet and PA, developing curriculum to enhance capacity of student leaders, conducting activities to encourage PA among students, creating a supportive environment, providing healthy food in the cafeteria, evaluating nutrition status and database, conducting obesity prevention program among parents and school personnel, integrating nutrition and PA education into school curriculum, organizing campaigns to prevent childhood obesity, controlling sale of food in school cafeteria, and enhancing family and school collaboration | *(continued)*

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intervention at week 12 and was repeated at weeks 24 and 48. Cliff et al\(^8\) had a follow-up at 36 weeks after a 10-week intervention program. The participants in the study by Dale et al\(^{24}\) were followed up at 8, 12, and 24 months after a 4-month lifestyle intervention. In the study by Okely et al,\(^{15}\) follow-up was at 6 and 12 months after the intervention ended. In the Sirikulchayanonta et al\(^{16}\) study, a postnutritional survey was held at 8 months.

**Outcome Measures**

The studies used quantitative as well as qualitative variables to measure the efficacy of intervention programs. Measurement techniques included physical assessments, blood biochemistry, and behavioral monitoring as well as psychological assessments.

All the studies that examined the impact of PA interventions took anthropometric measurements such as height and weight. Some studies that examined the impact of PA (38%) also assessed body composition.\(^{13,17,18,21,26,27}\) Blood pressure was measured in 6 studies (38%).\(^{13,20,21,23,24,26}\) PA was either measured directly using accelerometers\(^{8,18}\) or indirectly through questionnaires.\(^{16,20}\) A number of studies included blood biochemistry measurements, including cholesterol, glucose, and insulin (38%).\(^{13,15,20,23,24,26}\) Choi\(^{23}\) also tested for aspartate aminotransferase, alanine aminotransferase, adipocyte fatty acid-binding protein, lipocalin, retinol-binding protein 4, high-sensitivity C-reactive protein, and interleukin-6, whereas Campbell et al\(^{21}\) measured VLDL, and Wycherley et al\(^{26}\) measured urinary nitrate/nitrite. Only a few studies examined psychological measures. The study by Brennan et al\(^{18}\) included the largest number of psychological variables—anxiety, stress, depression, and self-esteem. Other studies only included 1 psychosocial measure. Chen et al\(^{22}\) assessed quality of life, Ha et al\(^{27}\) monitored depression, and O’Connor et al\(^{20}\) measured self-esteem.

In the studies that examined the effect of interventions to increase PA, Pal et al\(^{30}\) and Rowley et al\(^{29}\) took anthropometric measurements. Pal et al\(^{30}\) measured PA using pedometers, whereas Rowley et al\(^{29}\) used questionnaires.

**Significance of Results**

Studies of the impact of PA on obesity variables showed statistically significant (typically \(P < .05\), but some studies reported \(P < .01\) or lower) results for a number of variables. Chen et al\(^{22}\)
reported significant weight loss in their sample, whereas Choi et al\textsuperscript{23} found decrease in weight, BMI, waist circumference, and serum adipocyte fatty acid-binding protein levels. Ha et al\textsuperscript{27} found significant decrease in body fat and waist to hip ratio. McGuigan et al\textsuperscript{17} reported a significant decrease in percentage of body fat and increase in lean body mass. Sirikulchayanonta et al\textsuperscript{16} identified a significant increase in aerobic exercise activity and a decline in obesity. In a study to increase PA, Pal et al\textsuperscript{30} found a significant increase in PA and significant decrease in systolic blood pressure in their intervention group.

Ngoc Diep et al\textsuperscript{14} found a significant decrease in the percentage of obesity and improved dietary habits. O’Connor et al\textsuperscript{20} also demonstrated improved dietary habits in addition to significant improvements in self-perception scores, waist circumference, and HDL cholesterol. Rush et al\textsuperscript{13} reported a significant decrease in body weight, total and percentage body fat, waist girth, abdominal fat, and LDL and total cholesterol to HDL ratio. The intervention group in the study by Chang et al\textsuperscript{19} had significantly improved BMI, triglycerides, fasting serum glucose, and insulin levels; homeostatic model assessment for insulin resistance; strength; flexibility; and endurance. Wycherley et al\textsuperscript{26} reported reduced body weight; reductions in body fat, waist circumference, blood pressure, glycated hemoglobin, glucose, insulin resistance, lipids, and malondialdehyde; and increases in urinary nitrite/nitrate. In their study, Campbell et al\textsuperscript{21} found a significant difference only in VLDL levels in the intervention group. Krasilshchikov et al\textsuperscript{25} reported improvements in pain and physical function score, knee extensor concentric peak torque at 120 and 180 s, and 6-minute walking distance.

Studies also showed that some effects of intervention programs could be maintained at follow-up. Cliff et al\textsuperscript{8} found a significant increase in motor development, perceived athletic competence, and perceived global self-worth at posttreatment and 9-month follow-up but no change in BMI. The weight loss reported in Chen et al\textsuperscript{22} was sustained for up to 6 months and even 12 months. Sirikulchayanonta et al\textsuperscript{16} reported that there was an increase in PA after 8 months of the project. Okely et al\textsuperscript{15} found that weight loss was sustained at 12 months. In the other follow-up studies, there was no significant long-term effect. Chang et al\textsuperscript{19} reported that serum triglycerides, glucose, insulin, and homeostatic model assessment for insulin resistance levels returned to preintervention levels 3 months after the 9-month intervention. At the 2-year follow-up, Dale et al\textsuperscript{24} reported no significant weight differences between the intervention groups and the control group.

Discussion

In this review, we identified 16 studies involving Asia-Pacific samples that examined the impact of PA programs on outcomes in obese people. Of these studies, 56\% (9 studies) were conducted in Australia or New Zealand, 44\% (7 studies) were carried out in mainland Asia, and no studies focused on Pacific Island samples. Furthermore, in the review, we sourced 3 papers that presented interventions designed to increase PA among samples from the Asia-Pacific region. There were 67\% (2 studies) in Australia or New Zealand, 33\% (1 study) in Asia, and no studies in Pacific Island countries (PICs).

The research that has been conducted in Asia and the Pacific to examine the effect of PA on outcomes related to the management of obesity shows limited replication in specific populations and cultural contexts. In addition, the samples represent different demographics, such as children, adolescents, adults, and older adults, so comparison between them is often not appropriate. Many of the intervention programs involved small samples. The studies that had large samples were typically school-based intervention programs.\textsuperscript{14,16}

Furthermore, the PA programs varied between studies—for example, some studies examined PA alone, whereas others combined PA with diet or nutrition as well as psychological strategies.
Studies used diverse outcome measures, including biomedical indicators, such as metabolic variables, body composition, and cardiovascular fitness; psychological measures, such as depression and quality of life; and various indicators of PA. At this time, there appears to be little basis on which to draw conclusions for countries in Asia and the Pacific that PA of a specified type is beneficial for the promotion of outcomes that should enhance health and well-being among obese people from those locations—a conclusion that is established for obese populations in some other parts of the world. It is because of the combination of (a) a limited number of studies that met our criteria for review and (b) their diversity across a range of important variables that we have presented here a narrative review rather than a meta-analysis or systematic review. Examination of research on the impact of PA on obesity and interventions to increase PA in the Asia-Pacific region was worthwhile at this time because it does highlight the paucity of systematic research in some of the populations that head the world rankings for the scale of obesity and the rapidity with which it is increasing.

Thus, it is recommended that research in the Asia-Pacific on the effects of PA in obese people should be conducted according to systematic criteria, using standardized protocols, so patterns can be accumulated related to critical outcomes that reflect the influence of biological, demographic, and sociocultural variables. For example, Pacific Island studies should be considered together but separate from studies among populations in South East Asia, North East Asia, or the Indian subcontinent. The content and delivery of PA programs should be very similar, and outcome measures should be consistent across different studies to reduce noise caused by variations in programs. Research on children, adults, and older people should be conducted separately and compared within those categories. Based on the strong evidence from research in other regions, it is proposed that systematic research in targeted populations in the Asia-Pacific region will identify issues specific to this region that affect the content, delivery, and outcomes of PA programs. Once patterns are determined within a population, comparisons between populations that take into account key factors, including gender, age, body composition, and culture, could show where systematic differences between countries or cultures exist. In this way, it will be possible to more precisely specify the most effective PA interventions for different populations within the Asia-Pacific region.

In parts of the world such as Europe and North America, evidence from research indicates that PA is beneficial for people who are obese. This is reflected in reviews based on substantial numbers of studies that have demonstrated health benefits of PA for people who are obese. Thus, the focus of enquiry has largely moved to the question of how to promote sustained increases in PA among obese people. The present review shows that there is little research on this question in the Asia-Pacific region. Research in Western countries has reported successful interventions to promote PA in adults and children who are obese. Only 3 studies were identified, with just one in mainland Asia and none in PICs. Long-term change in a behavior like PA is highly dependent on perceptions, attitudes, and beliefs. Thus, it is critical that intervention programs intended to promote PA are contextualized in relation to social and cultural factors. Research should systematically examine the key sociocultural moderators of PA behavior change among different populations in the Asia-Pacific region. Intervention programs reported to be effective among North American or European people who are obese may not have a similar impact in the very different context of a Pacific Island or a developing country with a traditional culture in South East Asia. Among the limited number of PA behavior change studies that have been conducted in Asia-Pacific countries, some do show promise—for example, Chotibang et al, Burke et al, and Thomas et al, but there is an urgent need for careful replication and extension of these initial research outcomes.

Despite the very limited research evidence on PA behavior change in the whole Asia-Pacific region and, more particularly, the absence of any studies in PICs, a recent “stocktake” in these
countries, undertaken in the context of the high NCD risk in many PIC populations, identified 84 PA programs in operation across 20 of the 22 PICs. PICs represent a small proportion of the population of the Asia-Pacific region, but this exemplifies the extent of application of PA promotion programs in this region that were developed for use in populations in other parts of the world. This transfer of programs to populations that are very different from the populations in which they were developed has occurred while research on key variables influencing PA behavior in the Asia-Pacific is very limited. It is understandable that governments in countries identified to have high risk of NCDs such as obesity feel the need to act, but action that is not based on appropriate evidence could be perceived as a shot in the dark.

Conclusion
Obesity is at the heart of the current concern about the morbidity and mortality associated with NCDs worldwide. Many countries in the Asia-Pacific region rank high on lists of prevalence for obesity, yet systematic research on the impact of PA on the management of obesity and study of the efficacy of PA behavior change interventions are in their infancy, especially in critical areas in mainland Asia and the Pacific Islands where the prevalence of obesity is already high or is increasing rapidly. Further research focusing on these issues and designed to systematically examine key questions is urgently needed to effectively address the epidemic of obesity and its consequences in the Asia-Pacific region.

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