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1 **A 20-year report in physical activity and obesity among**
2 **preschool children in western countries and China**

3

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20

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23 **Abstract**

24 Childhood obesity is a global public health issue. Physical activity (PA)
25 plays an important role in the prevention of becoming obese and
26 reducing the risk of obesity. This report aims to explore the trend of
27 PA and its effects on obesity among preschool children (aged 3-7
28 years) in different cultural contexts (*i.e.*, western countries and China).
29 Five databases {English database (*i.e.*, PubMed) and the four main
30 Chinese journal databases, including CBM, CNKI, CQVIP, and
31 Wanfangdata}, were searched for studies published between 2002
32 and 2022. Five Chinese studies were included in the article. These
33 papers demonstrated that comprehensive intervention including
34 physical activity can prevent and relieve preschool children's obesity.
35 Eleven English studies met the inclusion criteria. Seven of them
36 indicated that the intervention groups reduce obesity among
37 preschool children, but in four of them, there is no significant
38 difference. Overall, the results suggested that PA affects obesity in
39 preschool children to a certain extent and demonstrated the need to
40 perform new studies in this specific population to prevent their
41 health better.

42

43 **Keywords:** physical activity; obesity; preschool children.

44

45 **1. Introduction**

46

47 Obesity is a chronic disease and a risk factor for other conditions
48 such as diabetes, cardiovascular disease, hypertension, and specific
49 types of cancer[1, 2]. Due to the widespread and rapid growth of
50 obesity worldwide and its health risks, it has become a recognized
51 global public health problem. Childhood obesity should be a public
52 health priority because it increases the risk of chronic diseases in
53 adulthood. Compared to children with healthy weights, for example,
54 children under six who are obese are four to five times more likely to
55 become obese once adults[3].

56 Since the 1970s, with the rapid growth of the global economy,
57 obesity among preschool children has become prevalent mainly in
58 developed western countries such as Europe and the USA[4].
59 According to data from the International Obesity Task Force (IOTF)
60 and the WHO, however, childhood obesity rates have increased
61 globally and are no longer a problem only in such developed
62 countries[5]. With continuing economic developments of large
63 countries such as China and India, these numbers are likely to further
64 increase within the next decade[6]. China, as the largest low- and
65 middle-income country, faces a challenge from the burden of
66 obesity. We compared PA and obesity between the Western

67 countries and China to determine if there are differences in the types,
68 intensity, and duration of PA and the relationship of obesity.

69 For example, the prevalence of obesity has doubled in more than
70 70 countries since 1980[7, 8]. According to the Global Burden of
71 Disease Study, a total of 107.7 million (5%) children worldwide were
72 estimated to be obese in 2015[9]. Moreover, overweight and obesity
73 prevalence taken together was even as high as 23%[9, 10].

74 Obesity is characterized by excess body fat resulting from a
75 positive energy balance (*i.e.*, energy intake greater than energy
76 expenditure)[11]. Along with excessive sedentary behavior, calories
77 intake, and poor sleep, lack of PA causes childhood obesity[15]. The
78 preschool period is debatably considered as a critical period during
79 which the long-term regulation of energy balance may be
80 programmed[12, 13]. In addition to playing a vital role in preventing
81 overweight and obesity, PA is essential for the normal growth and
82 development of children and adolescents[14, 15], and reduces the
83 health risks of chronic conditions[16].

84 Most studies on the relationship between obesity and PA focused
85 on adults and adolescents, whereas relevant studies on preschool
86 children remain limited. In China, with the rapid changes in dietary
87 patterns and lifestyles, the problem of childhood obesity has become
88 increasingly serious[17].

89 In this context, the objectives of the report were: 1) to explore the
90 trend of PA and obesity among preschool children in different
91 sociocultural and environment contexts (*i.e.*, western countries and
92 China), and 2) to determine the potential link between PA and
93 obesity in this specific population.

94

95 **2. Methods**

96

97 *2.1 Search strategy*

98 We conducted a scoping search on literature written in Chinese
99 and English.

100 To be completely immerse in the Chinese specific context we
101 chose to search only the Chinese written literature on the topic of PA,
102 obesity, and preschool children. Thus, we searched four of the main
103 Chinese medical databases, including CBM
104 (<http://www.sinomed.ac.cn/index.jsp>), CNKI (<https://www.cnki.net/>),
105 CQVIP (<http://www.cqvip.com>), and Wanfangdata
106 (<http://www.wanfangdata.com.cn>)] and an English database
107 (PubMed). The period of the literature search was 20 years (from
108 2002 to 2022). For the Chinese literature search, we used the
109 keywords"肥胖 (obesity)" AND"体育运动 (physical activity)" AND"学
110 龄前儿童 (preschool children)".

111 For the English literature search, we used the keywords “obesity”
112 AND “physical activity” AND “preschool children” and focused only
113 on randomized controlled trials (RCTs). We focused on RCTs to
114 ensure the highest evidence level for the cause-and-effect
115 associations between PA and obesity in preschool children.

116 We finally screened the titles and abstracts of all references for
117 potential correlates of obesity, physical activity, and preschool
118 children to come to the first selection of articles. During a second
119 screening, the remaining papers were fully read to come to the final
120 selection, and after careful consideration, these papers were included
121 in the report.

122

123 *2.2 Inclusion and exclusion criteria*

124 The screening was based on inclusion and exclusion criteria.
125 Inclusion criteria were as follows: (i) studies that examined obesity, (ii)
126 studies that examined correlates of physical activity, (iii) studies with
127 an age range of preschool children from 3 to 7 years old, and (iv)
128 only full-text articles written in Chinese or English. Furthermore, the
129 following exclusion criteria were applied: (i) reviews, (ii) studies that
130 were not conducted on humans, (iii) studies addressing other
131 behaviors (*i.e.*, breastfeeding, nutrition, and diseases), and (iv) studies
132 addressing clinical populations.

133

134 *2.3 Data extraction and analysis*

135 We performed data extraction from included studies using a
136 structured form including author, year of publication, country of the
137 study, study sample, follow-up period, target population, obesity
138 prevalence, types of intervention of PA (*i.e.*, questionnaire,
139 accelerometers), and main results.

140

141 **3. Results**

142

143 In total, 1,656 Chinese written papers were retrieved (40 in CBM,
144 1,594 in CNKI, 8 in CQVIP, and 14 in Wanfangdata). After the
145 selection process, five articles were considered in the writing of the
146 report.

147 In addition, 348 English written RCTs were identified after further
148 selection based on the titles and abstracts and, subsequently, the full
149 text articles. Eleven English published papers were included in the
150 present report. The procedure for excluding papers is reported in
151 Figure 1.

152

153 *3.1 Study characteristics*

154

155 Five published Chinese studies were included in this report.
156 These studies all focused on urban areas. The sample sizes of three
157 studies were between 100 and 999 participants [18-20]. One study
158 enrolled 4919 participants[21]. One study included two kindergartens
159 but no specific numbers[22]. The sample size varied from 106 to 4919
160 participants.

161 A total of eleven published English studies were selected. Four
162 were conducted in the USA[23-26], two of them were conducted in
163 Spain[27, 28], and the others were conducted in Israel[29], England[30],
164 Canada[31], Scotland[32], and China[33]. Of the eleven studies
165 included, three studies (27.27%)[26, 29, 31] had a sample size below
166 100, six studies (54.54%)[23, 25, 27, 30, 32, 33] were between 100 and
167 999, and two studies (18.18%)[24, 28] was above 1000 participants.
168 The sample size varied from 54 to 1898 participants.

169

170 *3.2 Relationship between physical activity and obesity among* 171 *preschool children*

172

173 In the five Chinese studies, the studies used comprehensive
174 interventions, notably including diet, PA, education, family, and
175 kindergarten. These studies did not explain the relationship between
176 each factor and obesity, and they did not explicitly describe the

177 measurement of PA. These papers showed that the PA measurement
178 was done by recording.

179 The table 1 presents Chinese studies' outcomes, number of
180 participants, follow-up period, target populations, types of
181 interventions, and main results. From table 1, it can be identified that
182 the preschool children were living in urban areas only. The main
183 results are that preschool children's obesity had been globally
184 reduced through comprehensive intervention.

185 However, there are some limitations in these Chinese studies. First,
186 these papers did not elaborate on the relationships between diet, PA,
187 education, family, kindergarten and obesity or BMI. Second, the
188 authors generalized the diet, PA, education, family, kindergarten and
189 obesity or BMI, into a whole that they called comprehensive
190 intervention. Therefore, it is difficult to precisely determine why these
191 comprehensive interventions allowed the reduction of preschool
192 children's obesity. Third, the literature did not describe the types and
193 measurements of PA, or through one sentence detail the types and
194 just recording PA.

195 For English studies, the interventions were usually precise such as
196 diet or nutrition and PA. The relationship between the intervention
197 factors and preschool children's obesity was clearly explained. More
198 objective measurements of PA in preschool children (7 studies on 11)

199 were used in these studies such as accelerometers, pedometers, and
200 hand-grip dynamometers. One study used questionnaires, one study
201 recorded the PA, and another two studies did not explain how they
202 measured PA in preschool children.

203 Seven studies indicated that there were significant differences
204 between intervention groups and control groups. The PA prevented
205 or reduced preschool children's obesity. However, four studies
206 showed that PA had little effect on obesity at the same time. Six
207 studies of them referred to diet or nutrition and PA. They elaborated
208 on the relationship between diet or nutrition, PA, and obesity
209 separately.

210 The table 2 presents English studies' data outcomes, number of
211 participants, follow-up period, target populations, types of
212 interventions, and main results. The table 2 shows that the target
213 population of the research partly were low-income families living in
214 rural and urban areas. Most of the papers did not precise it. Globally,
215 the main results of these English studies are that children from the
216 intervention group improved their body composition, and increased
217 the time as being physical active.

218 However, these studies have some limitations. First, using
219 equipment to measure PA may be more objective than
220 questionnaires and recordings, but preschool children are a

221 particular group. They may need to be used to wearing such
222 equipment and taking it off, which may lead to biased results. At the
223 same time, this could require supervision by teachers and parents.
224 Second, although the intervention lasted several weeks, several
225 months, a year or two years, outcomes were assessed immediately
226 after the intervention ended. Thus, there is no data on a long-term
227 effect of such interventions (*e.g.*, measurement 6 months or 1 year
228 after the intervention) in preschool children.

229

230 *3.3 Differences between English studies and Chinese studies*

231

232 Chinese studies recorded PA and did not elaborate on the
233 relationship between PA and obesity. They considered PA, diet,
234 education and other factors as a whole factor, called comprehensive
235 intervention. For researchers, it is difficult to explain the relationships
236 between obesity and one of the Chinese comprehensive
237 interventions.

238 Most English studies used equipment such as accelerometers or
239 pedometers to record PA, and few studies used questionnaires or
240 recorded PA. Most English research explains the relationships
241 between PA and obesity and brought a more comprehensive
242 explanation of the impacts of PA in very young children.

243

244 **4. Discussion**

245

246 In this present report, five Chinese studies and eleven English
247 studies investigated the link between PA and obesity in preschool
248 children. In the five Chinese studies, the main results indicated that
249 obesity rates have been reduced significantly after the
250 comprehensive interventions including diet, PA and education. In
251 one of these papers [21], the authors divided the population into
252 kindergarten and family interventions. They compared the effect of
253 diet, PA and education separately according to the living areas of the
254 population. Globally they reported that intervention groups
255 presented a decrease in body weight and BMI compared to the
256 control groups.

257 The five Chinese papers showed that the comprehensive
258 intervention method aimed at dietary adjustment, increasing PA and
259 health education globally prevent obesity prevalence in preschool
260 children. However, it is not possible to precisely determine which
261 factor is essential to obtain such result and no data are available on
262 the effect of the living area on the practice of PA and the prevalence
263 of obesity in these very young children.

264 In the eleven English articles, Abbey Alkon[23] and Alon Eliakim[29]

265 agreed that nutrition and PA intervention play a role in health
266 promotion, prevention and treatment of childhood obesity. More
267 precisely, they reported that nutrition and PA intervention can lower
268 BMI for children. Sally M. Davis[24] believed that at the end of the
269 intervention of eating and exercise, there was no significant
270 difference between the two groups in BMI z-scores. Vanessa Er et al.
271 [30] found a positive association between PA and BMI z-scores.
272 Likewise, they found evidence of higher PA levels increasing the
273 likelihood of being obese or overweight. Gary S. Goldfield[31] and
274 James J. Annesi[25] reported that increasing PA can significantly
275 reduce children's BMI. E.S Kuhl *et al.*, [26] found that lifestyle behavior
276 including healthy diet, increasing PA and decreasing television time,
277 could help preschoolers achieve healthy weight outcomes. Esteve
278 Llargues *et al.*, [27] thought that the promotion of healthy eating
279 habits and PA could reduce the prevalence of overweight and obese
280 children. John J Reilly *et al.*, [32] found that PA can significantly
281 improve motor skills but could not reduce BMI in young children in
282 their trial. Sijie Tan *et al.*, [33] demonstrated that PA decrease BMI,
283 waist circumference and blood pressure of obese children. Vicente
284 Martínez-Vizcaíno *et al.*, [28] found no significant improvement in
285 obesity with the intervention compared with the control group.
286 Further, PA did not alter other adiposity indicators and blood

287 pressure parameters in their preschool children.

288 To sum up, in these English papers, six articles[[23](#), [25](#), [27](#), [29](#), [31](#), [33](#)]
289 showed significant differences between PA and obesity or BMI,
290 meaning that increasing PA effectively reduced BMI or prevented
291 obesity in preschool children. Three articles[[24](#), [28](#), [32](#)] indicated that
292 after interventions of PA, there was no significant difference between
293 the intervention and the control group concerning the BMI. One
294 article[[30](#)] showed that higher PA levels increased the likelihood of
295 being obese and one paper[[26](#)] showed that preschoolers
296 experienced a significant decrease in BMI after the lifestyle behaviors
297 changes(*e.g.*, reduction of sugar-sweetened beverage intake,
298 increased fruit and vegetable intake, increased PA, and decreased
299 television time).

300 The included Chinese studies and English studies show that
301 obesity is relieved through comprehensive intervention or PA.
302 However, most English studies tried to explain and describe the
303 relationships between PA and obesity, or BMI and Chinese studies
304 did not. They usually use comprehensive factors like diet, PA, family,
305 kindergarten together to describe preschool children's obesity and
306 trend of PA.

307 Overall, for the majority of English studies and for all Chinese
308 studies included in the present report, results implied that PA is

309 helpful for the prevention of obesity in preschool children. The PA
310 can improve obesity among preschool children. It is noteworthy that
311 three English studies indicated no statistically significant relationship
312 between PA and obesity and one study showed that increased PA
313 increase the likelihood of being obese. These discrepancies are
314 commonly due to the lack of objective measures of PA. Thus, it is not
315 clear whether social and cultural environment could influence obesity
316 and the practice of PA in preschool children. In addition, it is not
317 possible to determine what kind of PA is useful to prevent obesity in
318 preschool children and what are the physiological effects behind this
319 prevention.

320 According to the World Health Organization (WHO)
321 recommendations, the PA protects children against the occurrence
322 of overweight and obesity[34]. Research studies have shown that
323 preschool children do not regularly engage in the recommended 60
324 minutes of moderate to vigorous PA each day[35], while other studies
325 found that they spend much of their time in sedentary behaviors [36-
326 38]. One study found that children spend more time in moderate to
327 vigorous physical activity when childcare programs have moveable
328 playground equipment (*e.g.*, balls, tricycles), lower use of electronic
329 media, and larger playgrounds compared to programs without these
330 characteristics[39].

331 Based on the above discussions, we suggest that preschool
332 children should do moderate PA, not only to keep from becoming
333 obese during their adulthood, but also for their health and growth.
334 To the extent of our knowledge, it is the first report describing trends
335 in PA and obesity among preschool children in Western countries
336 and China. Despite the tendency of a global beneficial effect of PA
337 on obesity in preschool children in Western countries and China they
338 are some issues concerning the type of PA, the intensity, the
339 duration, the frequency of PA, the objective measurement of PA and
340 its real physiological and cognitive impacts on these very young
341 children. There are also issues concerning the differential impact of
342 PA between very young girls and boys. In this context, we suggest
343 that preschool children may benefit from small sessions of PA (30
344 minutes per day), every days of the week using the high intensity
345 interval training type (high intensity PA sessions interspaced by
346 period of rest). PA should focus on all part of the children's body
347 (lower and upper limbs) to expect a global effect for the
348 development of their bones and muscles. PA sessions should include
349 game and group interactions which may increase the motivation of
350 children to exercise. In the absence of clear preschool children PA
351 recommendations, we hypothesize that this kind of PA should be
352 effective to prevent obesity in preschool children.

353

354 **Limitations:** The present report has some limitations. First, it was
355 difficult to find Chinese papers in Chinese scientific database
356 depending on the sonogram used and its multiple significations. That
357 is why we specified the sonograms used in this report. In addition,
358 Miss Jianhong Han is Chinese so it helps a lot for this part of the
359 search. Second, it was difficult to compare western countries and
360 China results because of the small number of papers concerned.
361 However, this put in evidence the need of research in this important
362 topic to prevent obesity in very young children all over the world.
363 Finally, the present report was not registered in PROSPERO but this is
364 not a systematic review or a meta-analysis. We used the word
365 “report” rather than “review” for this reason. However, this does not
366 preclude the quality and integrity of the contents in the present
367 report.

368 **5. Conclusion**

369 The aim of the current report was to explore the trends and effects
370 of PA on obesity among preschool children in different sociocultural
371 and environment contexts (western countries and China).

372 Of the included five Chinese studies and eleven English studies,
373 twelve papers of them demonstrated that PA improved the situation
374 of obesity in preschool children, except four English studies. All

375 Chinese studies and most of the English studies conclude that PA
376 reduces obesity to a certain extent. However, some English studies
377 show no statistically significant relationship between PA and obesity
378 and one study showed that increased PA increases the likelihood of
379 being obese. Based on these findings, it can be inferred that
380 adequate PA may prevent preschool children's obesity and is
381 beneficial for the health and growth of preschool children. Future
382 studies are needed to precise the types of PA, its intensity, frequency,
383 duration and to explore the social and cultural impacts on the active
384 behavior of preschool children and the prevalence of obesity in this
385 specific population. Future research is needed to explore what types
386 of PA and PA intensity are more effective for preventing obesity in
387 preschool children.

388

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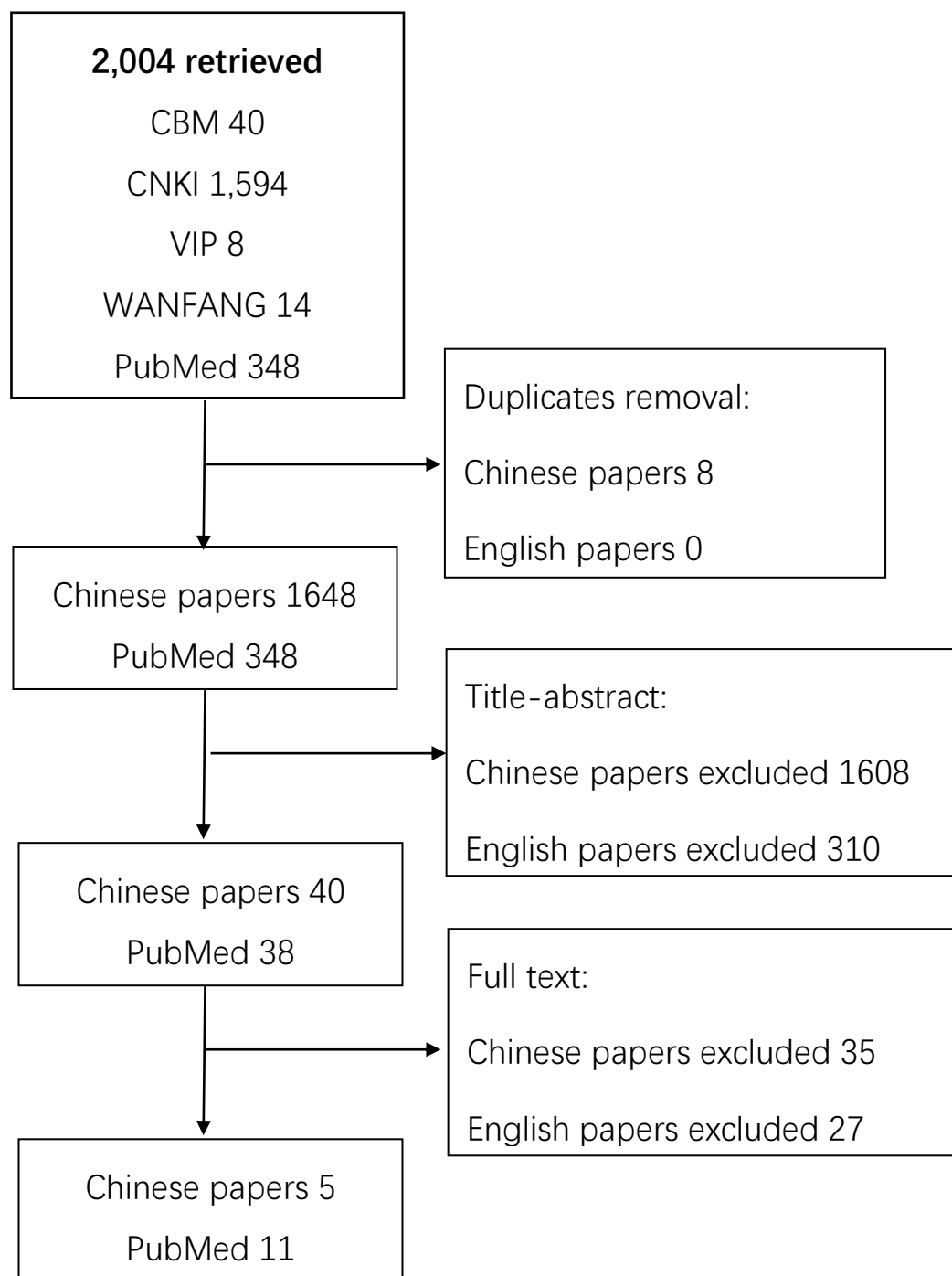


Figure.1: Flow chart of included articles

Table 1 Characteristics of the Chinese study sample

Author	Year	Title	Sample Size	Age (Year (s old	Target Population	main results	intervention	Time Period
马玉丽	2007	儿童单纯性肥胖综合干预途径及方法研究	188	3-6	urban	The weight was somewhat controlled in the intervention group; as to the height, there was no difference between two groups. The epidemic change of obesity and overweight in the intervention group was controlled better than the control one. The parents' knowledge on healthcare giving was significantly improved. at the end of intervention, the Z score of BMI decreased in the intervention group both for boys and girls, while it increased for boys and a little decreased for girls in the control group. At the end of study, for intervention group, the incidence of overweight was unchanged, while the incidence of obesity changed from 5.1% to 6.3%. for the control group, the incidence of overweight changed from 19.5% to 16.9% while and incidence of obesity turned from 9.8% to 14.9%.	comprehensive intervention	2004.09 - 2005.06
蒋一方	2006	上海市某幼儿园单纯性肥胖综合干预的动态研究	339		urban		comprehensive intervention	2004.09 - 2005.06
孔繁香	2015	黑河市城区3~5岁集居儿童肥胖情况调查及干预效果初步探讨	106	3-5	urban	after intervention, obese children rehabilitation efficiency of the study group was 28.30%, the control group was 3.78%.	comprehensive intervention	2014.07 -12

薛惠娟	2007	两所幼儿园 儿童单纯性 肥胖干预效 果观察	NA	urban	In the first 6 months of experimental kindergarten, the incidence of intervening obese children was significantly increased (from 6.6% to 12.2%), and the incidence of intervening obese children was significantly reduced ($P < 0.05$). The incidence of obese children in Luocheng kindergarten has increased slightly year by year. The two kindergartens have stopped obesity intervention, and the incidence of obesity has increased significantly.	diet physical activity education	three years
马志君	2012	学龄儿童肥 胖干预方法 对比分析	4919	urban	The height of each group increased before and after the experiment; the weight and BMI decreased except for the control group.	family kinderg arden	one year

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Author	Year	title	country	Sample Size	Age Years (old)	Target Population	main results	intervention	Time Period
Abbey Alkon	2014	Nutrition and physical activity randomized control trial in childcare centers improves knowledge, policies, and children's body mass index	USA	552	5-3	low-income families	Hierarchical linear models and multiple regression models assessed individual- and center-level changes in knowledge, policies, practices, and age- and sex-specific standardized body mass index (zBMI), controlling for state, parent education, and poverty level. Results showed significant increases in	nutrition and physical activity	7 months

Alon Eliakim	2007	The Effects of Nutritional-Physical Activity School-based Intervention on Fatness and Fitness in Preschool Children	Israel	54	5-6	NA	providers' and parents' knowledge of nutrition and physical activity, center-level improvements in policies, and child-level changes in children's zBMI based on 209 children in the intervention and control centers at both pre- and post-intervention time points. Daily physical activity was significantly greater in the intervention group compared to the controls (6,927 +/- 364 vs 5,489 +/- 284 steps/ day, respectively; p < 0.003). Favorable changes were observed in weight (0.35 +/- 0.08 vs 0.9 +/- 0.1 kg, p < 0.0005), BMI percentile (-3.8 +/- 1.3 vs 2.9 +/- 1.5 kg/m ² , p < 0.001), fat percent (by skinfolds, -0.65 +/- 0.3 vs 1.64 +/- 0.3%, p < 0.028) and fitness (endurance time -3.55 +/- 1.85 vs 3.16 +/- 2.05%, p < 0.017) in the intervention versus control groups.	nutrition and physical activity	4 months
Sally M. Davis	2016	CHILE: Outcomes of a group randomized controlled trial of an intervention to prevent obesity in preschool Hispanic and American Indian children	USA	189	<=4 8 4-6	rural community	At baseline, demographic characteristics in the comparison and intervention groups were similar, and 33% of all the children assessed were obese or overweight. At the end of the intervention, there was no significant difference between the two groups in BMI z-scores	diet and physical activity	2 years 1 year

Vanesa Er	2018	Association of diet in nurseries and physical activity with zBMI in 2-4-year olds in England: a cross-sectional study	England	150	2-4	NA	Among children who consumed one main meal or snack at childcare, 34.4% and 74.3% met the standards on fruits and vegetables and high sugar or fat snacks, respectively. Adherence to CFT guidelines was not associated with zBMI. Only 11.4% of children met recommended UK guidelines of three hours per day of physical activity. Minutes spent in light PA ($\beta = 0.08$, 95% CI = 0.01, 0.15) and active time ($\beta = 0.07$, 95% CI = 0.01, 0.12) were positively associated with UK 1990 zBMI scores. Linear mixed-effects modeling showed that at 6 months, children in the intervention group demonstrated greater increases in minutes per preschool day spent in overall PA (22.5 minutes, 95% CI=8.9, 36.1, $p=0.002$), and light-intensity PA (16.1 minutes, 95% CI=5.2, 26.7, $p=0.004$), but changes between groups in moderate to vigorous PA did not differ. The intervention group showed greater reductions in body fat percentage (-1.9%, 95% CI=-3.5, -0.3, $p=0.023$) and fat mass (-0.3 kg, 95% CI=-0.7, -0.1, $p=0.018$), but groups did not differ on fat-free mass, BMI, or z-BMI. Findings indicated a significant increase	diet and physical activity	1 year
Gary S. Goldfield, PhD,	2016	Effects of Child Care Intervention on Physical Activity and Body Composition	Canada	83	3-5	NA	Linear mixed-effects modeling showed that at 6 months, children in the intervention group demonstrated greater increases in minutes per preschool day spent in overall PA (22.5 minutes, 95% CI=8.9, 36.1, $p=0.002$), and light-intensity PA (16.1 minutes, 95% CI=5.2, 26.7, $p=0.004$), but changes between groups in moderate to vigorous PA did not differ. The intervention group showed greater reductions in body fat percentage (-1.9%, 95% CI=-3.5, -0.3, $p=0.023$) and fat mass (-0.3 kg, 95% CI=-0.7, -0.1, $p=0.018$), but groups did not differ on fat-free mass, BMI, or z-BMI. Findings indicated a significant increase	physical activity	6 months
James	2013	Reducing high BMI in	USA	273	4-5	low	Findings indicated a significant increase	physical	9

J. Annesi		African American preschoolers: effects of a behavior-based physical activity intervention on caloric expenditure				income	in accelerometer-measured moderate-to-vigorous and vigorous physical activity during the 7-hour school day. Reductions in body mass index (BMI; kg/m) were significant, with greater effects found in participants with an initially higher BMI. Further analyses indicated that the kilocalories expended through physical activity explained approximately 87% of the weight lost. Participants' sex did not affect the identified changes in BMI.	activity	months
E.S. Kuhl	2014	Examination of the association between lifestyle behavior changes and weight outcomes in preschoolers receiving treatment for obesity	USA	60	2-5	NA	Despite significant reductions in sugar-sweetened beverage intake and television use, and increases in fruit and vegetable intake, only reductions in absolute caloric intake significantly predicted reductions in BMI z score. Two years after the beginning of the study, the body mass index of the children in the control group was 0.8 kg/m(2) higher than that of the intervention schools—the intervention reduced by 62% the prevalence of overweight children. Similarly, the proportion of children that ate a second piece of fruit and took part in an after-school physical activity increased in the intervention group. In the control group, the weekly consumption of fish was	diet and physical activity	6 months
Esteve Llargues	2011	Assessment of a school-based intervention in eating habits and physical activity in school children: the AVall study	Spain	184	5-6	city		diet and physical activity	2 years

John J Reilly	2006	Physical activity to prevent obesity in young children: cluster randomized controlled trial	Scotland	545	4.2	NA	reduced. Group allocation had no significant effect on the primary outcome measure at six and 12 months or on measures of physical activity and sedentary behaviour by accelerometry. Children in the intervention group had significantly higher performance in movement skills tests than control children at six-month follow-up (P=0.0027; 95% confidence interval 0.3 to 1.3) after adjustment for sex and baseline performance. The physical activity program was successfully completed, and no sport injury occurred. Exercise training decreased BMI, waist circumference, body fat%, and fat mass; and slowed down the growth speed of body mass of both trained obese and lean children. Exercise training significantly decreased systolic blood pressure of obese children and decreased their heart rate responses during exercise. Trained obese children improved the performances of long jump, 10-m × 4 shuttle run, and 3-m balance beam walk; while trained lean children improved more items of physical fitness.	physical activity	24 weeks
Sijie Tan	2017	Exercise Training Improved Body Composition, Cardiovascular Function, and Physical Fitness of 5-Year-Old Children with obesity or normal body Mass	China	104	5	NA	There was no significant improvement in	physical activity	10 weeks
Vicen	2019	Effectiveness of a school-	Spain	143	4-7	province		physical	8

te Marti nez- Vizca íno	based physical activity intervention on adiposity, fitness, and blood pressure: MOVI-KIDS study	n	4	s	overweight/obesity with the intervention compared with the control group in both sexes. Further, the intervention did not alter other adiposity indicators or BP parameters. Improvements in cardiorespiratory fitness were seen in girls (1.19; 95% CI 0.31 to 2.08; p=0.008), but not in boys. Finally, there was an improvement in velocity/agility in both girls (-2.51 s; 95% CI -3.98 to -1.05; p=0.001) and boys (-2.35 s; 95% CI -3.71 to -0.98; p=0.001), and in muscular strength in both girls (0.66; 95% CI 0.03 to 1.28; p=0.038) and boys (1.26; 95% CI 0.03 to 1.28; p<0.001).	activity month s
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