

GARDENING INTERVENTIONS FOR CHILDREN

1

Abstract

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Background: Although there are numerous health benefits associated with eating fruit and vegetables (FV), few children are consuming recommended amounts. Gardening interventions have been implemented in various settings in an effort to increase FV consumption of children by expanding knowledge, exposure, and preferences for a variety of FV.

Objective: The purpose of this review was to identify the effectiveness of gardening interventions that have been implemented to increase FV consumption among children.

Methods: A systematic review was conducted using four electronic databases: Web of Science, PubMed, Scopus, and CINAHL. English language studies conducted in developed countries between January 2005 and October 2015 were included in this review. Included studies measured FV consumption of children ages 2-15 years old before and after implementation of a gardening intervention in a school, community, or after school setting. All study designs were included in this review. A total of 891 articles were identified through database searching and cross-referencing. After removing duplicates, 650 articles remained and were screened using inclusion and exclusion criteria. Twenty-seven full text articles were analyzed and 14 articles were included in this review.

Results: Of the 14 articles reviewed, 10 articles found statistically significant increases in fruit or vegetable consumption among participants after implementation of a gardening intervention. However, many studies were limited by the use of convenience samples, small sample sizes, and self-reported measurements of FV consumption.

Conclusions: Although the evidence is mixed and fraught with limitations, most studies suggest a small but positive impact of gardening interventions on children's FV intake. Future studies

25 that include control groups, randomized designs, and assessments of FV consumption over at
26 least one year are needed to advance the literature on this topic.

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48 Introduction

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50 Diets rich in fruits and vegetables (FV) have been associated with obesity and chronic
51 disease prevention as well as improved overall health status among adults¹⁻⁶ due to the high
52 amounts of fiber and phytonutrients found in FV.⁷⁻⁸ Despite the long-term benefits associated
53 with consuming adequate FV, less than half of children in the United States are meeting the
54 recommended intakes provided by the Dietary Guidelines for Americans.⁹ Development of
55 healthy eating behaviors during childhood has been associated with healthy food choices into
56 late adulthood, therefore it may be important for children to consume a variety of FV at a young
57 age.¹⁰ Numerous public health programs and policies have been implemented to increase FV
58 intake among children in effort to improve lifelong healthy eating habits and therefore reduce
59 their risk of developing chronic disease.

60 Gardening-based programs have been implemented in school and community settings as
61 a way to increase consumption of FV in children.¹¹⁻¹⁵ However, most studies to date have
62 measured determinants of dietary behaviors such as knowledge, attitudes, and preferences for FV
63 as opposed to changes in dietary intake.^{12, 14-17} A systematic review of 11 studies investigating
64 garden-based intervention programs in children found that only four studies assessed FV intake
65 while the majority of studies investigated other factors such as knowledge, preferences, beliefs
66 and values, and willingness to taste FV.¹⁸ Authors of this review concluded that gardening
67 interventions increase willingness to try FV among young children and increase preferences for
68 FV among children whose preferences for FV had previously been low.¹⁸ Although these factors
69 are important determinants of FV consumption, assessment of nutritional intake through 24-hour
70 recalls, Food Frequency Questionnaires (FFQ) and objective measurement tools such as blood

71 and skin carotenoid levels, more accurately assess FV intake among this age group.^{19,20}
72 Gardening interventions may be an effective strategy for increasing FV intake by teaching
73 school-aged children how to plant, grow, harvest, and prepare FV.¹⁸ Furthermore, encouraging
74 children to regularly participate in gardening activities is consistent with the literature which
75 suggests that regular exposure to FV increases consumption among this age group.^{21,22}

76 Increasing the consumption of FV among children has the potential to reduce the risk of
77 chronic disease and has been found to improve long-term health outcomes. There is a need to
78 investigate the current peer-reviewed literature to determine if gardening interventions improve
79 dietary intake of children. The primary purpose of this review was to identify the effectiveness of
80 gardening interventions that have been implemented to improve FV consumption among
81 children ages 2-15 years old in school, community, and afterschool settings. This review focuses
82 on studies that assessed FV consumption. It augments previous systematic reviews¹⁸ and meta-
83 analysis²³ that primarily examined changes in FV knowledge, preferences, and attitudes.

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Methods

87 Search Strategy

88 A systematic review of published literature on 14 studies investigating FV consumption
89 among children receiving gardening interventions was conducted based on protocols established
90 for reviews through Preferred Reporting Items for Systematic Reviews and Meta-Analyses.²⁴
91 The databases Web of Science, PubMed, Scopus, and CINAHL were searched for MeSH terms
92 and terms found in titles and abstracts of applicable studies. In addition, the following keywords
93 were searched individually and in various combinations: youth, children, child, gardening, fruit

94 and vegetable, fruit, vegetable, nutrition, school, consumption, and intervention. Search
95 strategies used for each database are listed in Table 1.

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97 **Study Selection**

98 Studies meeting the following criteria were included: published in the English language
99 between January 1 2005 and October 31 2015, conducted in developed countries, utilized
100 gardening interventions, targeted children ages 2-18 years old, and measured FV consumption.
101 For the purpose of this review, gardening-based interventions were defined as any gardening-
102 related programming through outside gardens, micro-farms, container gardens or other
103 alternative gardening methods that allowed children to receive hands-on experience with
104 planting, growing, and harvesting FV. Excluding studies from less developed countries ensured a
105 more homogeneous sample. Interventions could include any garden-related school-based, after
106 school, or community-based program. Due to the relatively small number of available studies, all
107 study designs were included in this review. Studies in which actual FV consumption was not
108 measured before and after the intervention, or for which FV consumption was assessed using a
109 single question were excluded. Studies investigating only knowledge, attitudes, beliefs,
110 intentions, preferences, or other determinants of FV consumption or that implemented programs
111 outside the target population were excluded. Multicomponent interventions were excluded if the
112 gardening component was not discussed and evaluated in detail. Qualitative studies and studies
113 that were not published in peer-reviewed journals or that were published only as an abstract from
114 a conference proceeding and not a full paper were also excluded.

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116 **Data Extraction**

117 One author independently reviewed all of the papers identified using the selection criteria
118 as outline above using a standardized data extraction form. The data extracted from each study
119 can be found in Table 2.

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121 **Methodological Quality Assessment**

122 The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool was used
123 to assess the quality of each study included in this review.^{25,26} This tool was used to rate
124 individual studies on a variety of components including selection bias, study design,
125 confounders, blinding, data collection methods, withdrawals and dropouts, intervention integrity,
126 and analysis. Each component was rated numerically as strong (score=1), moderate (score=2) or
127 weak (score=3) in the global rating system.^{25,26} A strong paper (score=1) had no weak ratings,
128 moderate papers (score=2) had one weak rating, and weak papers (score=3) had two or more
129 weak ratings.^{25,26} Two reviewers independently evaluated the 14 studies using the EPHPP
130 Quality Assessment Tool. A final study quality was determined when two reviewers compared
131 study component ratings and agreed on a final decision.^{25,26}

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133 **Results**

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135 **Study Selection**

136 A total of 887 abstracts were identified in the databases using MeSH terms and keywords
137 with an additional 4 articles identified from searching reference lists. Of these, 241 articles were
138 duplicates resulting in a screening of 650 titles and abstracts. An additional 623 articles were
139 excluded after screening for eligibility. Of the 27 remaining full text articles reviewed, 13 were

140 eliminated as a result of the inclusion and exclusion criteria listed above. The process by which
141 studies were included in this review can be found in Figure 1.

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143 **Study characteristics**

144 The reviewed studies were conducted in four developed countries: United States,²⁷⁻³⁶
145 United Kingdom,^{37,38} Australia,³⁹ and Canada.⁴⁰ U.S. based studies were conducted in various
146 regions including those in warmer and cooler climates. Although search criteria included
147 children ages 2-18 years old, the studies included in this review only provided gardening
148 interventions to children ages 2-15 years old, with the majority of programs (86%) primarily
149 targeting elementary aged children.^{27,28,31,32,33,34,35,36,37,38,39,40}

150 Duration of gardening interventions ranged from 10 weeks to 18 months with most
151 interventions lasting between 10-16 weeks. Nine of the studies were conducted in the school
152 setting, utilizing classroom time and school curricula for program implementation.³²⁻⁴⁰ In the
153 remaining five studies, gardening programs were implemented in community, afterschool, and
154 childcare settings.²⁷⁻³¹ Sample sizes in the reviewed studies ranged between 77-641 children with
155 the majority of sample sizes between 100-300 children. The gardening interventions typically
156 included the opportunity for children to plant, water, weed, harvest, and taste an assortment of
157 FV. Several curricula were used in the studies included in this review with two studies that used
158 the LA Sprouts curriculum.^{29,30}

159 The identified studies used a variety of experimental designs. Ten of the 14 studies
160 included in this review used a design that included a control or comparison group^{27-29, 32-35, 37-39}
161 and the other four studies conducted a pretest-posttest design^{30,31,36,40} Convenience samples were
162 commonly used, however, three studies^{28,29,37} did randomize either the children or the schools in

163 the study. Only three studies followed students for a year or longer to evaluate long-term effects
164 of the intervention.^{35,37,40} FV consumption was operationalized in three ways: amounts,
165 frequency, and variety of consumption. Diverse evaluation tools and techniques were used with a
166 wide range in validity, reliability, and rigor. Evaluation tools used to determine changes in FV
167 consumption included 24 hour dietary recalls,^{31,32,39} food diaries,³⁵ the Block Kids Food
168 Screener,^{27,28,33} structured dietary observation,^{29,34} Child and Diet Evaluation Tool,³⁷ Day in the
169 Life Questionnaire,³⁸ and the Garden Vegetable Frequency Questionnaire.³⁶ Select studies also
170 used instruments that had not been previously validated.^{30,40}

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172 **Study Quality**

173 Based on the EPHPP Quality Assessment Tool criteria, one study was considered
174 strong²⁸, one study was considered moderate³⁸, and 12 studies were considered weak.^{27,29-37,39-40}
175 The most common study limitations were selection bias and external validity as a result of the
176 use of convenience samples and small sample sizes, respectively. Among the individual studies,
177 eight studies^{27,28,31,32,36-38} used validated measurement tools and four studies reported
178 reliability.^{27,28,37,38} In the four studies that were randomized,^{28,29,33,37} the nature of the intervention
179 did not allow for blinding of participants or researchers. Twelve studies in this review<sup>27,28,30-
180 33,35,36-40</sup> relied on self-reported measurements of FV consumption.

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182 **Randomized Controlled Trials**

183 None of the three randomized controlled trials found statistically significant changes in
184 FV consumption after children participated in gardening interventions.^{28,29,37} Gatto & colleagues
185 found that FV consumption did not significantly increase among children (3rd-5th graders) in the

186 intervention group (n=172), however, dietary fiber consumption increased by 0.4g/day among
187 the intervention group as compared to a decrease of 2.0g/day among the control group (P=0.04,
188 n=147).²⁸ In the study by Namenek Brouwer & Neelon, children (3-5 years old) in the
189 intervention group (n=38) consumed a mean increase of 0.25 servings of vegetables per day as
190 compared to mean decrease of -0.18 servings per day in the control group (n=38).²⁹ However,
191 this paper did not include any significance testing so it is unclear if this finding is statistically
192 significant or not.²⁹ Christian & colleagues found no significant changes in fruit or vegetable
193 consumption among children (7-11 years old) in either the Royal Horticulture Society-led group
194 (n=312) or the Teacher-led group (n=329), two intervention groups that received varying degrees
195 of assistance with implementing school based gardening interventions.³⁷ When FV were
196 combined in an unadjusted model, children in the Teacher-led group consumed significantly
197 more FV (P=0.05) after the intervention as compared to the Royal Horticultural Society-led
198 group.³⁷ However, significance was not maintained after adjusting for confounders such as age,
199 gender, and ethnicity (P=0.06).³⁷

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201 **Nonequivalent Groups Design Studies**

202 Six studies in the sample used non-randomized intervention and control groups.^{32-34,36,38,39}
203 Four of these found increased intakes of either fruit or vegetables in the gardening intervention
204 group.^{32,34,36,38} McAleese & Rankin found a significant increase in fruit (P<0.001) and vegetable
205 (P<0.001) consumption among children (6th graders) in the nutrition education and gardening
206 group (n=45) with fruit increasing by 1.13 servings per day and vegetables increasing by 1.44
207 servings per day.³² FV consumption did not significantly change in the control (n=25) or
208 nutrition education only group (n=25).³² Duncan & colleagues also found a significant increase

209 (P=0.01) in FV consumption among children (1st-5th graders) in the intervention group (n=46,
210 mean±SD=1.4±1.5 portions per day) while no significant change (P>0.1) was found in the
211 control group (n=31).³⁸ Parmer & colleagues determined vegetable consumption by visual
212 inspections of plates before and after lunchtime at the pre and post assessment.³⁴ Consumption of
213 vegetables significantly increased among the gardening and nutrition education group (n=39, 2nd
214 graders) (P<0.01) from pre to post assessment.³⁴ No changes were found in the nutrition
215 education only group and the control group ate significantly fewer vegetables at the post
216 assessment (P<0.001).³⁴ Ratcliffe & colleagues found that although the variety of vegetables
217 consumed during the school day significantly increased (P<0.01) when comparing the
218 intervention group (n=170, 11-13 year olds) to the control group (n=150, 11-13 year olds),
219 vegetable consumption at home did not significantly change (P=0.12).³⁶

220 Two of the nonequivalent groups design studies found no significant change in FV
221 consumption.^{33,39} Morgan & colleagues found no significant difference in fruit (P=0.23) or
222 vegetable (P=0.22) consumption in children (5th-6th graders) in either of the treatment groups or
223 the control group over the intervention period.³⁹ Similarly, Meinen and colleagues did not find a
224 significant change in FV consumption from pretest to posttest in either the intervention or control
225 group among older children (n=801; 3rd-7th graders) who completed their own surveys.³³ The
226 intervention group did see a significant increase in fruit (P<0.01) and vegetable (P<0.05)
227 consumption as reported by parents of younger children (n=995, 2nd graders and younger).³³

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229 **Pretest Posttest Studies**

230 There were three studies that used a pretest posttest study design to compared FV
231 consumption before and after receiving a gardening intervention.^{27,30,31} Two studies found

232 significant increases in FV consumption.^{30,31} Castro & colleagues found the average number of
233 FV significantly ($P<0.001$) increased among children ($n=120$, 2-5 years old) after participating in
234 Growing Healthy Kids Program ($n=120$) with fruits increasing by 28% and vegetables increasing
235 by 33% each day.³⁰ Lautenschlager & Smith found a significant increase in fruit ($P=0.029$) and
236 vegetable ($P=0.007$) consumption among boys ($n=42$, 8-15 years old) after participating in the
237 gardening intervention.³¹ Fruit ($P=0.253$) and vegetables ($P=0.682$) consumption did not
238 significantly increase among girls ($n=54$, 8-15 years old).³¹ However, girls in this study had
239 higher intakes of FV at baseline as compared to boys.³¹

240 One study that used a pretest-posttest study design did not find a significant increase in
241 FV consumption.²⁷ Davis & colleagues found that dietary fiber intake increased by 22% in the
242 intervention group ($n=34$) compared to a 12% decrease in the control group ($P=0.04$, $n=70$) from
243 pre to post intervention.²⁷ However, similar to the study conducted by Gatto & colleagues, FV
244 consumption did not significantly change among either group so it is unlikely that the higher
245 fiber intake resulted from increased FV consumption.^{27,28}

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247 **Prospective Cohort Studies**

248 Only two studies followed gardening intervention cohorts over time to determine long-
249 term changes in FV consumption.^{35,40} Hanbazaza & colleagues asked children ($n=116$, 1st-6th
250 graders) at baseline, 7-month follow-up, and 18-month follow-up if they consumed certain
251 vegetables at home during each data collection using yes/no questions.⁴⁰ There were no
252 significant changes in the consumption of fruit or vegetables reported at any time point.⁴⁰
253 However, this study did not directly measure FV consumption. Wang & colleagues found that
254 children ($n=327$, 4th-5th graders) with the greatest exposure to the intervention (gardening classes,

255 cooking classes, improved school meals and dining, and gardening/cooking lesson) increased FV
256 consumption by roughly 0.5 cups/day while children with little to no intervention decreased FV
257 consumption by 0.3 cups/day.³⁵ As a result of the multicomponent intervention used in this
258 study, there is no way to determine specifically if the gardening component of the intervention
259 influenced behavior change among participants.³⁵

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Discussion

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264 This review of the impact of gardening interventions on FV consumption among children
265 included 14 studies with considerable diversity in study design, sample size, and tools used to
266 measure FV consumption. Ten studies found that participating in various gardening interventions
267 was associated with significantly greater FV consumption.^{27-35,38} However, four other studies
268 indicated no significant changes in FV consumption.^{36,37,39,40} Furthermore, minimal data
269 regarding long-term changes in FV consumption has been collected therefore there is no way to
270 determine if changes in FV consumption are sustained over time. In fact, the long-term benefits
271 associated with implementing gardening programs for children remains in question suggesting a
272 need for further research.

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274 Although many studies have reported significant improvements in preferences,
275 knowledge, and attitudes towards FV,^{12,14-17} increases in FV consumption were not consistently
276 found among studies presented in this review. While gardening interventions increase access to
277 FV during the school day, it is possible that children have limited access to FV at home resulting
in minimal changes in FV consumption over the intervention period.³⁶ Ratcliffe and colleagues³⁶

278 and Namenek Brouwer and colleagues²⁹ found that although the variety of vegetables consumed
279 at school increased, consumption of vegetables at home did not change. Gardening interventions
280 for children may benefit from incorporating a parental component to increase the likelihood that
281 FV are available for children at home to allow for increased consumption.^{36,37} Future studies
282 should compare the effectiveness of a traditional gardening intervention program to gardening
283 interventions that incorporate resources and support for parents to encourage changes in FV
284 consumption when children are not in school.

285 Three studies in this review supplemented gardening interventions with nutrition
286 education to increase FV consumption by enhancing knowledge and increasing exposure of
287 FV.^{32, 34,39} When compared to children who did not receive an intervention and to those who
288 received nutrition education only, children who received gardening and nutrition education
289 combined were found to have greater increases in FV consumption over the intervention period
290 in two out of three studies.^{32,34} Multi-component interventions have been found to be more
291 effective at changing nutrition-related behaviors than single-component interventions among
292 children.⁴² Although results are not conclusive, these studies suggest that the combination of
293 gardening and nutrition education may be an effective intervention for increasing FV
294 consumption. Future studies should be conducted to determine if interventions that incorporate
295 hands-on gardening experiences, nutrition education, and parent involvement are more effective
296 than interventions that provide gardening experiences only. Further research should also be done
297 to determine which educational strategies actually contribute to behavior change among garden
298 intervention participants.

299 Most studies in this review investigated changes in consumption of both FV even though
300 only four studies reported planting fruit,^{27,29,30,32} most commonly strawberries and melons, as

301 part of the gardening intervention. It is likely that the limited exposure to fruit through this
302 intervention impacted the effectiveness of increasing fruit consumption among participants.
303 Although most studies combine FV in general discussion about these food groups and in actual
304 measurement of them, there has been evidence to suggest that nutrition-related interventions
305 should target fruit and vegetables separately as a result of the different factors influencing
306 consumption such as knowledge, barriers, and stages of change.⁴³ Furthermore, there is growing
307 evidence that consumption of vegetables among children presents a much greater challenge than
308 consumption of fruit.⁴⁴ Future studies in this area should report fruit and vegetable outcomes
309 separately, and consider carefully whether or not they should include fruit consumption as an
310 outcome.

311 The duration and intensity of the gardening interventions provided to children varied
312 greatly among the studies in this review. Morgan and colleagues³⁹ conducted a high intensity 10
313 week gardening intervention of 45 minutes four times per week and found that participation in
314 the gardening intervention was not associated with increased FV consumption. Two other high
315 intensity gardening interventions that provided 90 minute weekly sessions of gardening for 12
316 weeks also concluded that FV consumption did not significantly change among participants.^{27,28}
317 Conflicting results were found in a study comparable in duration and intensity.³⁸ Furthermore,
318 several studies did not indicate the intensity of the gardening interventions implemented^{29,31-}
319 ^{34,37,40} which makes it difficult to determine the dose-response of the change in FV consumption
320 at varying levels of exposure to gardening interventions. Consequently, a direct comparison of
321 study results was not possible in this review. The intensity and length of gardening interventions
322 should be further investigated and compared to determine the most effective method for
323 implementing gardening interventions for children.

324 The studies included in this review included widely different ages of children from 2-15
325 years. From the results presented here, there is no evidence that gardening interventions are more
326 effective in certain age ranges. Ages of children should be considered when developing and
327 implementing gardening based interventions to ensure program effectiveness. Children learn
328 differently at every age resulting in the need for variation in learning objectives, educational
329 strategies, and activities offered to each age group.⁴⁵ Although many studies in this review used
330 age appropriate evaluation tools, there was no mention of consideration regarding age during
331 program and curriculum development. Many studies offered the same gardening-based
332 interventions to a large age range of children^{31,37,38,40} with the largest age range spanning from 2-
333 13 year old.³³ Authors of future studies should consider using evidence-based curricula that are
334 age specific to ensure the intervention is tailored to the developmental stage of their intended
335 audience. In addition, future studies should be conducted to determine if gardening interventions
336 are more effective among certain age ranges of children. Results of studies should be stratified
337 by age if they include wide age ranges and if sample size permits.

338 Although the results from studies presented in this review provide valuable insight into
339 the effectiveness of gardening interventions on FV consumption among children, there are
340 significant limitations. Most importantly, only three studies conducted randomization of either
341 children or schools.^{28,29,37} Without randomization, researchers increase the risk for selection bias,
342 systematic differences among study groups, and less accurate interpretation of the effects of the
343 intervention.⁴⁶ Cohort and quasi-experimental study designs were used for the remaining studies,
344 which have numerous limitations including the lack of randomized control groups, influence of
345 confounding variables, threats to internal validity, and overall weaker conclusions.⁴⁷ Other flaws
346 in study design including the use of convenience samples and unblended experiments may have

347 resulted in multiple type of bias, therefore, limiting the generalizability of the results. Blinding
348 researchers that implement the gardening interventions is not feasible, but future studies should
349 consider blinding researchers whose role is limited to collecting dietary intake data from
350 participants. RTCs with larger sample sizes should be used in future studies to limit potential
351 bias and to determine if causality exists between participation in gardening-based interventions
352 and changes in FV consumption.

353 FV consumption was measured using a variety of self-reported instruments, which may
354 have influenced the results of this review. Self-reported measurement tools are susceptible to
355 social approval bias and therefore may not accurately represent change in dietary intake.⁴⁸
356 Further, only half of studies reported validity and reliability of measurement tools, which may
357 limit the accuracy of results in those studies. Most studies used 24-hour recalls^{31,32,35,37,39} or the
358 Block Kids Food Screener^{27,28,33} to measure changes in FV consumption. Although 24 hour
359 recalls are state of the art for measuring individual dietary intake, misreporting of dietary intake
360 can occur especially among children 12 years of age and younger⁴⁹ which may have influenced
361 the accuracy of results in numerous studies. Future studies should consider including more
362 objective measures of FV consumption in addition to 24-hour recalls to give a more complete
363 picture of changes in FV consumption. For example, skin carotenoid levels can be assessed using
364 resonance Raman spectroscopy, a noninvasive alternative to measuring serum carotenoids that
365 has been used as a valid objective indicator of FV consumption among children.^{50,51}

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Conclusion

Gardening-based interventions have been implemented around the country with an overall goal of improving health-related behaviors of children in school and community settings. Although the evidence is somewhat mixed, most available studies suggest a small but positive impact of gardening interventions on children's FV consumption. Recommendations for future research include investigating long term changes in FV consumption, the impact of parental components of gardening based interventions on FV consumption of participating children, the effects of duration and intensity of programs, and the use of age-specific curriculum on program outcomes. Additional research that addresses the limitations discussed here should be conducted and would strengthen the available evidence regarding the efficacy of gardening-based interventions to increase children's FV consumption.

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