Gamification for the Improvement of Diet, Nutritional Habits, and Body Composition in Children and Adolescents: A Systematic Review and Meta-Analysis

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Abstract: Currently, one of the main public health problems among children and adolescents is poor adherence to healthy habits, leading to increasingly high rates of obesity and the comorbidities that accompany obesity. Early interventions are necessary, and among them, the use of gamification can be an effective method. The objective was to analyse the effect of game-based interventions (gamification) for improving nutritional habits, knowledge, and changes in body composition. A systematic review and meta-analysis were performed in CINAHL, EMBASE, LILACS, MEDLINE, SciELO, and Scopus databases, following the PRISMA recommendations. There was no restriction by year of publication or language. Only randomized controlled trials were included. Twenty-three articles were found. After the intervention, the consumption of fruit and vegetables increased, as well as the knowledge on healthy food groups. The means difference showed a higher nutritional knowledge score in the intervention group 95% CI 0.88 (0.05–1.75). No significant effect of gamification was found for body mass index z-score. Gamification could be an effective method to improve nutritional knowledge about healthier nutritional habits. Promoting the development of effective educational tools to support learning related to nutrition is necessary in order to avoid and prevent chronic diseases.

Keywords: adolescents; children; dietary behaviour; game; gamification; healthy eating; nutrition

1. Introduction

Nowadays, the absence of a physical exercise routine and adherence to a balanced diet are two major public health problems. In 2019, 38 million children under 5 years old were overweight or obese [1]. Furthermore, more than 80% of the adolescent population in the world does not do enough physical activity [2].

The WHO emphasizes that unhealthy diets and physical inactivity are two key risk factors to develop non-communicable diseases such as, cardiovascular diseases, cancer, and diabetes [3]. In addition, the intake of fruits and vegetables in the child population is under the recommended levels and that of sugar is well above the established limits, which increases the risk of developing these diseases [4].
Due to the lack of adherence to healthy habits in children and adolescents, a change in strategies focused on health promotion is required [5]. In this sense, gamification is a new, educative way that can be very useful to promote adherence to healthy habits [6].

Gamification is based on the application of game mechanics during the teaching–learning process [7]. In addition to using the intrinsic characteristics of a game, it also uses new technologies, the internet, and applications for mobile phones [8]. The characteristics of gaming are used to get achievements, prizes, or rewards [9]. This game dynamic is related to benefits at the learning level and increases the interaction between participants, offering freedom and increased motivation [10].

Gamification has been implemented in different areas of health and education. Benefits have been obtained in the improvement of healthy habits at the level of physical activity and nutrition in adults [7,11,12]. Gamification strategies have also been used in adolescents to improve sexual education [13,14] or to improve healthy habits, such as physical exercise and nutrition [15,16]. Many studies even focus on these interventions from an early age, for example, through interactive video games that improved physical activity [17–19], increased the number of daily steps [20,21], or improved cardiovascular parameters in the school population [22].

Due to the difficulty of inducing lifestyle changes in the young population, gamification can be an effective method to create change and improve adherence to healthy practices [6]. Some studies find that childhood is the ideal age to promote healthy habits, and resources such as social networks, mobile devices, or games can be very useful to promote knowledge and improve adherence [4].

Traditional interventions aimed at influencing fruit and vegetable intake among young people do not show extraordinary results [23]. There are few health applications that use gamification as an educational resource [24]. Given the need to carry out more innovative interventions focused on improving prevention strategies and policies, we performed this systematic review and meta-analysis in order to analyse behavioural changes in nutritional habits, knowledge, and body composition when using gamification as an educational resource.

The objective of this systematic review and meta-analysis was to analyse the effect of gamification for improving diet, nutritional habits, knowledge, and body composition in children and adolescents.

2. Methods
2.1. Design and Search Methods

A systematic review and meta-analysis was carried out following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines [25].

The following databases were consulted: CINAHL, EMBASE, LILACS, MEDLINE, SciELO, and Scopus. The search was carried out in April 2021. There was no restriction by year of publication. Using the Mesh terms, the search equation was “(game OR gamification) AND (child OR adolescent) AND (nutrition OR feeding behaviour OR food OR diet OR body composition OR body mass index OR health) AND (RCT OR randomized controlled trial)”.

For the selection of the study sample, the PICO (population, intervention, comparison, and outcome) strategy was used. The population were children and adolescents; the intervention was through different gamification programs (defined as organized games with a set of rules for playing and achieving goals or objectives by providing feedback and interaction); the comparison was made between the pre- and post-intervention groups, or the intervention and control groups; and the outcomes were diet and body composition improvement.

2.2. Inclusion and Exclusion Criteria

The studies with the following characteristics were included: (1) randomized controlled trials, (2) study sample comprising children and adolescents, (3) intervention as
a playful game component, (4) gathering data on the effect of the intervention on eating habits, knowledge, and body composition. There was no restriction by language or by year of publication.

The exclusion criteria were (1) studies related to improvement in other health habits, (2) interventions applied exclusively to certain diseases/pathologies, (3) combination with other types of interventions such as physical activity, (4) studies without a control group.

2.3. Study Selection, Quality Appraisal, and Risk of Bias

The selection was carried out by two authors independently. First, the title and abstract were read. Then the full text was read. Finally, a critical reading of the selected studies was carried out to assess the risk of bias. A third author was consulted in case of disagreement.

The quality of the studies was assessed following the levels of evidence and grades of recommendation of the Oxford Centre for Evidence-Based Medicine (OCEBM) (Howick et al., 2011) (Table 1). Risk of bias was analysed by pairs of independent reviewers using the Cochrane Collaboration risk of bias tool [26]. All the articles reached a quality level according to the quality assessment tools; therefore, no study was excluded.
Table 1. Characteristics of the included studies (n = 23).

| Authors, (Year), Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (M(SD)) | EL/RE |
|--------------------------|--------|--------|-----|-------------|----------|-------------|------------------------|-------|
| Amaro et al. [27] (2006), Italy | RCT | N = 241 children Age 11–14 year s CG = 88 s IG = 153 | To test the changes in nutrition knowledge and dietary behaviour | CG: no intervention IG: “Kaliko” Nutrition board-game (play session 15–30 min) | 24 weeks | Questionnaires on nutritional knowledge and food intake | BMI: Nutrition knowledge Significant difference between IG and CG at post-assessment (p < 0.05). Adjusted means were 11.24 (95% CI 10.68–11.80) for the IG and 9.24 (95% CI 8.50–9.98) for CG. | A/1 |
| Bannon et al. [28] (2006), USA | RCT | N = 50 children Mean age 5 years s CG = 18 s IG1 = 14 s IG2 = 18 | To test the influence of nutrition message framing on snack choice among children | CG: control video IG1: gain-framed nutrition video message IG2: loss-framed nutrition video message | 60 s video time | Food preference questionnaire | “Gain- and loss-framed messages promoting healthy snacks have the potential to positively influence children’s behaviour In IG, 56% chose apples rather than animal crackers, in CG, only 33% chose apples” | A/1 |
| Baños et al. [29] (2013), Spain | RCT | N = 228 children Age 10–13 years s CG = 155 s IG = 73 | To study an online game to improve children’s nutritional knowledge | CG: paper–pencil intervention IG: “ETIOBE Mates” broader e-therapy platform educational website including serious games | 2 weeks (unlimited sessions) | Nutritional knowledge questionnaire | | A/1 |
| Baranowski et al. [30] (2011), USA | RCT | N = 133 children Age 10–12 years s CG = 40 s IG = 93 | To promote behaviour change on children’s diet | CG: games on popular websites IG: “Escape from Didd” + “Invasion from Inner Space” Video-games (9 sessions of 40 min) | 2 months | BMI: Mean levels of FV, non-fat vegetables, total energy | | A/1 |
| Chagas et al. [31] (2020), Brazil | RCT | N = 319 adolescents Mean age 15.8 years s CG = 202 s IG = 117 | To assess the impact of a game-based nutritional intervention on food consumption, nutritional knowledge, and self-efficacy | CG: no intervention IG: “Range Cards”, a digital game (unlimited session) | 17 days | Nutritional knowledge questionnaire | | A/1 |
Table 1. Cont.

| Authors, (Year), Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (M(SD)) | EL/RG |
|--------------------------|--------|--------|-----|-------------|----------|-------------|-----------------------|-------|
| Cullen et al. [32] (2005), USA | RCT | N = 1469 children Age 8–12 years n CG = 740 n IG = 749 | To assess changes in nutritional practices | CG: no intervention IG: “Squire’s Quest” multimedia game (10 sessions of 25 min) | 5 weeks | Servings of fruit, 100% juice, and vegetables consumed | After intervention, at snacks, the difference in means between IG and CG was significantly higher for fruit and 100% fruit juice, and for regular non-fried vegetables but not for other juice and vegetables | lb/A |
| Cullen et al. [33] (2016), USA | RCT | N = 387 children Age 9–11 years n CG = 97 n IG1 action plans = 98 n IG2 coping plans = 95 n IG3 action + coping plans = 97 | To examine an online video-game to promote fruit-vegetable consumption changes | CG: no intervention IG: “Squire’s Quest II” online video-game. 10 sessions (25 min each) for 5 weeks | 5 weeks | Servings of fruit, 100% juice, and vegetables consumed | At 6 months, vegetable intake at dinner was significantly increased in intervention and coping groups. Overall, there were significant increases in fruit and vegetable intake at breakfast (p < 0.001), lunch (p = 0.014), and as a snack (p < 0.001) | lb/A |
| Folkvord et al. [34] (2013), Netherlands | RCT | N = 270 children Age 8–10 years n CG = 69 n IG1 = 69 n IG2 = 67 n IG3 = 65 | To examine the effect of advergames that promote intake of energy-dense snacks or fruit on children | CG: no intervention IG1: advergame that promoted energy-dense snacks IG2: advergame that promoted fruit IG3: non-food products | - | Caloric intake | Children who played an advergame that promoted food (energy-dense snacks or fruit) ate significantly more than did the children who played an advergame that promoted non-food products (p < 0.01) and also ate more snacks (male) (p < 0.05), hunger (p < 0.01), and age (p < 0.05) were significantly related to energy-dense caloric intake | lb/A |
| Froome et al. [35] (2020), Canada | RCT | N = 73 children Age 8–10 years n CG = 34 n IG = 39 | To determine improvement in children’s nutritional knowledge | CG: cooking game “My Salad Shop Bar” IG: game mobile application Foodbot Factory (learning module of drinks, whole-grain food, vegetables and fruits, animal protein, plant-based protein + voiceover) (10–15 min each day) | 5 days | Nutrition knowledge | | lb/A |
| Gan et al. [36] (2019), Philippines | RCT | N = 360 children Age 7–10 years n CG = 180 n IG = 180 | To increase nutrition knowledge | CG: no intervention IG: “Healthy Foodie” nutrition game (25 to 40 min to complete the game) | 2 weeks | Nutrition knowledge questionnaire | | lb/A |
| Hermans et al. [37] (2018), USA | RCT | N = 108 children Age 10–13 years n CG = 54 n IG = 50 | To test the short-term effectiveness of a videogame designed to teach elementary school children about nutrition and healthy food choices | CG: web-based nutrition game “Super Shopper” (not designed to educate children in healthy food choices) IG: gameplay of “Feed the Alien: Health Game” “Feed the Alien” (designed to educate children in healthy food choices and the main function of the five most important macro-nutrients; 1 h of gameplay (30 min session)) | 2 weeks | Nutrition knowledge | | lb/A |
Table 1. Cont.

| Authors, Year, Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (M(SD)) | EL/RG |
|------------------------|--------|--------|-----|-------------|----------|-------------|-----------------------|-------|
| Lakshman et al. [38](2010), UK | RCT | N = 1133 children Age 9–11 years n CG = 631 n IG = 502 | To increase nutrition knowledge | CG: traditional healthy eating curriculum IG: “Top Grub”: card nutrition game | 9 weeks | Nutrition knowledge questionnaire | Attitudes to healthy eating Baseline Nutrition knowledge Total score CG: 27.3 (2) IG: 28.1 (1.3) Balanced diet domain (max 0.15 points) CG: 11.3 (0.8) IG: 11.4 (0.4) Ability to identify healthier foods CG: 11.6 (0.9) IG: 12.1 (0.6) 9 weeks Nutrition knowledge Total score CG: 27.9 (2.3) IG: 26.2 (0.8) Balanced diet domain (max 0.15 points) CG: 11.5 (0.8) IG: 12.1 (0.5) Ability to identify healthier foods CG: 11.4 (0.9) IG: 12.1 (0.6) | Baseline vs. 2 months follow-up (Only for IG) Fruit, Vegetables Preference Baseline 68.36 (13.53)/71.54 (15.49) 2 months Fruit, vegetables, and water consumption Fruit/Vegetable Preference 68.36 (13.53)/71.54 (15.49) Water Preference 2.64 (0.65)/2.59 (0.72) Intrinsic Motivation for Fruit 5.89 (1.94)/6.15 (2.18) Intrinsic Motivation for Vegetable 3.76 (1.82)/3.73 (1.94) Intrinsic Motivation for Water 5.19 (1.95)/5.51 (1.91) Fruit Self-Efficacy 9.49 (2.12)/10.39 (2.29) Vegetable Self-Efficacy 4.69 (2.24)/5.32 (2.22) Water Self-Efficacy 3.56 (1.39)/3.69 (1.54) Story immersion correlated positively (p < 0.03) with an increase in Fruit and Vegetable Preference (r = 0.27), Intrinsic Motivation for Water (r = 0.29), Vegetable Self-Efficacy (r = 0.24) | b/A |
| Lu et al. [18](2012), USA | RCT | N = 153 children Age 10–12 years n CG = 50 n IG = 103 | To analyse positive health outcomes IG: no intervention | IG: health videogame “Escape from Diab” | 2 months | Fruit, vegetables, and water consumption Fruit/Vegetable Preference 68.36 (13.53)/71.54 (15.49) Water Preference 2.64 (0.65)/2.59 (0.72) Intrinsic Motivation for Fruit 5.89 (1.94)/6.15 (2.18) Intrinsic Motivation for Vegetable 3.76 (1.82)/3.73 (1.94) Intrinsic Motivation for Water 5.19 (1.95)/5.51 (1.91) Fruit Self-Efficacy 9.49 (2.12)/10.39 (2.29) Vegetable Self-Efficacy 4.69 (2.24)/5.32 (2.22) Water Self-Efficacy 3.56 (1.39)/3.69 (1.54) Story immersion correlated positively (p < 0.03) with an increase in Fruit and Vegetable Preference (r = 0.27), Intrinsic Motivation for Water (r = 0.29), Vegetable Self-Efficacy (r = 0.24) | b/A |
| Mack et al. [40](2020), Germany | RCT | N = 82 children Age 9–12 years n CG = 40 n IG = 42 | To evaluate the gain in knowledge about important lifestyle factors with the focus on nutrition CG: brochure healthy lifestyle IG: nutrition games modules (2 sessions of 45 min) | 2 weeks | Maintenance of knowledge questionnaire Food frequency questionnaire Healthy nutrition index Healthy nutrition index (reported by children) | CG: 49 (14) IG: 50 (13) % of dietary energy-density score CG: 44 (19) IG: 52 (30) Healthy nutrition index (reported by children) CG: 9.8 (2.2) IG: 8.8 (2.1) | Baseline Knowledge score % Food pyramid score CG: 49 (14) IG: 50 (13) % of dietary energy-density score CG: 44 (19) IG: 52 (30) Healthy nutrition index (reported by children) CG: 9.8 (2.2) IG: 8.8 (2.1) | b/A |
| Putnam et al. [41](2018), USA | RCT | N = 132 children Age 6–5 years n CG = 64 n IG = 68 | To encourage healthier snack selection and consumption CG: game adventure app IG: game adventure app with “Dora the Explorer” | - | Snack choices | Children who were aware of Dora were 10.34 times more likely to select healthier snack items than those who were unaware of her (p = 0.008) | b/A |
| Authors, Year, Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (M(SD)) | EL/RG |
|------------------------|--------|--------|-----|-------------|----------|-------------|-----------------------|-------|
| Sharma [42] (2015), USA | RCT | N = 94 children Age 8-12 years n CG = 50 n IG = 44 | To evaluate dietary behaviours | CG: usual programs IG: “Quest to Lava Mountain” adventure game (90 min play game) | 6 weeks | Dietary Intake (av. per 1000 kcal) | | |
|                         |        |        |     |             |          | Baseline          |                       |       |
|                         |        |        |     |             |          | CG: 8.82 (2.46)   | 6 weeks follow-up     |       |
|                         |        |        |     |             |          | IG: 9.29 (2.59)   |                       |       |
|                         |        |        |     |             |          | Sugars (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 55.35 (18.44) |                       |       |
|                         |        |        |     |             |          | IG: 59.35 (13.47) |                       |       |
|                         |        |        |     |             |          | Total fat (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 22.31 (6.03)  |                       |       |
|                         |        |        |     |             |          | IG: 22.84 (5.45)  |                       |       |
|                         |        |        |     |             |          | Energy (kcal)     |                       |       |
|                         |        |        |     |             |          | CG: 1422.53 (442.27) |                       |       |
|                         |        |        |     |             |          | IG: 1415.49 (412.02) |                       |       |
|                         |        |        |     |             |          | Carbohydrates (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 51.83 (7.97)  |                       |       |
|                         |        |        |     |             |          | IG: 49.79 (6.84)  |                       |       |
|                         |        |        |     |             |          | Protein (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 15.84 (3.71)  |                       |       |
|                         |        |        |     |             |          | IG: 17.37 (5.80)  |                       |       |
|                         |        |        |     |             |          | Calcium (mg/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 528.95 (180.32) |                       |       |
|                         |        |        |     |             |          | IG: 507.36 (186.07) |                       |       |
|                         |        |        |     |             |          | Dietary Intake (av. per 1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 0.79 (0.66)   |                       |       |
|                         |        |        |     |             |          | IG: 0.77 (0.67)   |                       |       |
|                         |        |        |     |             |          | Vegetables (servings per 1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 0.45 (0.27)   |                       |       |
|                         |        |        |     |             |          | IG: 0.50 (0.44)   |                       |       |
|                         |        |        |     |             |          | Dietary Intake (av. per 1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 7.96 (2.62)   |                       |       |
|                         |        |        |     |             |          | IG: 8.35 (2.61)   |                       |       |
|                         |        |        |     |             |          | Sugars (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 60.34 (15.67) |                       |       |
|                         |        |        |     |             |          | IG: 50.43 (18.05) |                       |       |
|                         |        |        |     |             |          | Total fat (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 22.31 (6.03)  |                       |       |
|                         |        |        |     |             |          | IG: 22.84 (5.45)  |                       |       |
|                         |        |        |     |             |          | Energy (kcal)     |                       |       |
|                         |        |        |     |             |          | CG: 1422.53 (442.27) |                       |       |
|                         |        |        |     |             |          | IG: 1415.49 (412.02) |                       |       |
|                         |        |        |     |             |          | Carbohydrates (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 51.83 (7.97)  |                       |       |
|                         |        |        |     |             |          | IG: 49.79 (6.84)  |                       |       |
|                         |        |        |     |             |          | Protein (g/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 15.84 (3.71)  |                       |       |
|                         |        |        |     |             |          | IG: 17.37 (5.80)  |                       |       |
|                         |        |        |     |             |          | Calcium (mg/1000 kcal) |                       |       |
|                         |        |        |     |             |          | CG: 528.95 (180.32) |                       |       |
|                         |        |        |     |             |          | IG: 507.36 (186.07) |                       |       |
Table 1. Cont.

| Authors, Year, Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (M(SD)) | EL/GR |
|------------------------|--------|--------|-----|-------------|----------|-------------|------------------------|--------|
| Sharps et al. [43] (2016), UK | RCT | N = 143 children Age 6–11 years  \( \text{CG: } 66 \) \( \text{IG1: } 49 \) \( \text{IG2: } 48 \) | To increase intake of fruit and vegetables through board games | CG: non-food-related game IC1: descriptive social norm-based message. Fruit and vegetables related game IC2: health message and image condition. Fruit and vegetables related game 7 min of playtime every day | - | Food intake | Significant main effect of condition on fruit and vegetable intake (\( p = 0.01 \)). IG2 ate significantly more fruit and vegetables than children in CG (\( p = 0.009 \)). There was no significant main effect of conditioning on high-calorie snack food intake (\( p = 0.99 \)). | Ib/A |
| Ross et al. [44] (2016), Italy | RCT | N = 145 children Age 8–10 years  \( \text{CG: } 33 \) \( \text{IG1: } 58 \) \( \text{IG2: } 54 \) | To improve nutritional education | CG: no intervention IC1: “Master of Taste” nutritional educator IC2: “Master of Taste” supported by a humanoid robot | 1 year | Cultural–nutritional awareness factor (score of the nutritional knowledge level) | Baseline \( CG: 5.5 (1.5) \) \( IC1: 6.2 (1.2) \) \( IC2: 5.4 (1.3) \) 1 year follow-up Cultural–nutritional awareness factor \( CG: 6.1 (1.4) \) \( IC1: 6.9 (1.3) \) \( IC2: 6.9 (1.3) \) | Ib/A |
| Spook et al. [45] (2016), Netherlands | RCT | N = 231 adolescents Mean age 17.28 years  \( \text{CG: } 126 \) \( \text{IG: } 105 \) | To assess dietary intake | CG: no intervention IC: “Balance II”, interactive multimedia game (unlimited access) | 4 weeks | Dietary intake (fruit and vegetable consumption, snack consumption, and soft drink consumption) | Baseline \( CG: 0.80 (0.68) \) \( IC: 0.81 (0.66) \) Vegetable intake \( CG: 1.28 (0.30) \) \( IC: 1.26 (0.33) \) Snack consumption \( CG: 1.11 (0.59) \) \( IC: 1.07 (0.55) \) Soft drink consumption \( CG: 1.11 (0.59) \) \( IC: 1.07 (0.55) \) 4 weeks follow-up Behavioral outcomes (mean portion/day) Fruit intake \( CG: 0.81 (0.62) \) \( IC: 1.05 (0.77) \) Vegetable intake \( CG: 1.26 (0.36) \) \( IC: 1.21 (0.41) \) Snack consumption \( CG: 0.80 (0.40) \) \( IC: 0.86 (0.53) \) Soft drink consumption \( CG: 1.11 (0.59) \) \( IC: 1.07 (0.55) \) | Ib/A |
| Authors, Year, Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (MSDI) | EL/RG |
|------------------------|--------|--------|-----|-------------|----------|-------------|----------------------|-------|
| Thompson et al. [46], (2016) USA | RCT | N = 387 children Aged 9–11 years | To evaluate the dietary intake of healthy children | CG: no intervention; Intervention: serious game “Squire’s Quest II” (10 sessions of 25 min) IC1: Action: set a goal and then created an action plan to meet the goal IC2: Coping: a goal to eat more FV and then to create a coping plan IC3: Both IC1 + IC2 | 5 weeks | Fruit and vegetable intake | | |
| Authors, Year, Country | Design | Sample | Aim | Intervention | Duration | Measurement | Main Outcomes (Mean ± (SD)) | EL/GR |
|------------------------|--------|--------|-----|-------------|----------|-------------|----------------------------|-------|
| Viggiano et al. [47] (2015), Italy | RCT | N = 3110 children Age 9–19 years | To promote nutrition education and to improve dietary behaviour | CG: no intervention IG: “Kalèdo” nutrition board-game (25–30 min session) | 20 weeks | BMI z-score Nutrition Knowledge | Baseline  
Normal Weight  
CG: 32.5%  
IG: 31.6%  
Overweight  
CG: 32.6%  
IG: 34.9%  
Obesity  
CG: 14.5%  
IG: 15.7%  
BMI z-score  
CG: 0.59  
IG: 0.58  
Nutrition Knowledge  
CG: 4.4 (4.2–4.5)  
IG: 4.2 (4.1–4.4)  
Food Habits  
CG: 27.5  
IG: 27.8 | 1B/A |
| Viggiano et al. [48] (2018), Italy | RCT | N = 1007 children Age 7–11 years  
= CG: 366  
= IG: 651 | To improve knowledge in nutrition and to promote a healthy lifestyle | CG: no intervention IG: “Kalèdo” nutrition board-game. 20 sessions of 15–30 min | 20 weeks | Food frequency consumption BMI z-score | 8 months follow-up  
IG significantly increased the consumption of healthy food (p < 0.01) compared to CG  
18 months follow-up  
The increase in the consumption of healthy foods in GI was maintained over time (p < 0.01). Significantly higher consumption of healthy food in girls (mean 9.4; CI 95% 7.61–11.22) compared to boys (mean 7.11; CI 95% 5.46–8.76). GI decreased junk food consumption (p < 0.01) compared to the CG | Baseline  
Number of fruit and vegetable serves  
CG: 1.95 (0.17)  
IG: 1.91 (0.13)  
BMI z-score  
CG: 0.31 (0.08)  
IG: 0.18 (0.06)  
More usual circumstance in cm  
CG: 52.53 (0.28)  
IG: 52.54 (0.23) | 1B/A |
| Zask et al. [49] (2012), Australia | RCT | N = 1005 children Age 3–6 years  
= CG: 563  
= IG: 442 | To increasing fruit and vegetable intake and decreasing unhealthy food consumption | CG: no intervention IG: “Tooty Fruity Vegie” a game health promotion program | 10 months | Dietary intake BMI | Baseline  
Number of fruit and vegetable serves  
CG: 1.70 (0.12)  
IG: 2.23 (0.11)  
BMI z-score  
CG: 0.28 (0.09)  
IG: 0.31 (0.08)  
More usual circumstance in cm  
CG: 55.69 (0.28)  
IG: 52.89 (0.29) | 1B/A |

BMI = body mass index; CG = control group; EL = evidence level; FV = fruit and vegetable; IG = intervention group; RCT = randomized controlled trial; RG = recommendation grade.
2.4. Data Abstraction

A descriptive analysis was performed to extract the data from each included study, consulting with a third author in case of disagreement. The variables obtained from the selected articles were (1) author, year of publication, country, (2) design, (3) sample size, (4) aim, (5) type of intervention and duration, (6) measuring instruments, and (7) main results.

The coding reliability was calculated according to the intraclass correlation coefficient, which gave a mean value of 0.96 (minimum = 0.92, maximum = 1), and Cohen’s kappa coefficient, mean value 0.93 (minimum = 0.92, maximum = 1).

2.5. Data Analysis

The meta-analysis compared the standardized means difference between the gamification group and the control group. The heterogeneity of the sample was assessed with the I² index, if this was greater than 50% a random-effects analysis was selected [26]. Publication bias was assessed using the funnel plot, and a sensitivity analysis was also performed. RevMan Web software was used.

3. Results

3.1. Study Characteristics

The database search comprised a total of 1433 articles. The final sample was \( n = 23 \) articles. The selection process is shown in Figure 1.

All included studies were clinical trials [27–49]. The total sample was 11,280 children and adolescents. The oldest article dates from 2005, although most studies were published from 2010 (\( n = 20 \)). Most of the studies were conducted in the USA (\( n = 8 \)) and Italy (\( n = 4 \)). The adherence rate to the intervention programs was high, from 96.4% [40] to 91% [42,46]. The main characteristics of all the included studies are listed in Table 1.
3.2. Effects of Gamification on Food Groups and Food Habits

Providing nutritional information through gamification interventions had a positive influence on food selection in children and adolescents. After the intervention, the consumption of certain food groups increased. Weekly intake of fruit \[28,35,39,49\] and vegetables \[27,33,35,39,49\] was augmented with an increase of about 0.67 servings per day up to 1 serving \[30,32\]. Intake of nutrients related to fruits and vegetables such as vitamin C, beta-carotene, potassium, and dietary fibre improved \[31,46\]. The consumption of whole and protein-rich foods was also increased \[35\], and the sugar intake decreased significantly \[42\]. Some authors when analysing water consumption did not find significant differences \[30\] although they increased motivation \[39\].

Knowledge about information related to food groups increased from 4.8% \[29\] up to 34.10% \[36\]. In addition, knowledge about the five major macronutrients improved after intervention, although not at follow-up \[37\]. It also improved self-efficacy in the adoption of healthy eating practices such as the preparation of healthy meals \[31\].

Regarding eating habits, after the intervention, the frequency of eating while watching television or studying as well as eating in fast food restaurants was reduced \[31\].

3.3. Effects of Gamification in Body Composition

Regarding changes in body composition, some authors found significantly lower changes after intervention in waist circumference and BMI z-score after intervention and follow-up \[47–49\]. Although other authors did not find significant differences after intervention \[27,30\].

3.4. Meta-Analysis Results and Risk of Bias

There was no publication bias, and no studies were removed after sensitivity analysis. Regarding nutritional knowledge variable, six studies provided the necessary data, with a final sample of \(n = 2574\) subjects in the intervention group and \(n = 2649\) in the control group. The standardized means difference, with the 95% confidence interval, was 0.88 (0.05–1.75) and displayed a statistically significant higher knowledge score in the values of the experimental group \((p < 0.05)\). These data mean that using gamification helps to improve nutritional knowledge about healthier nutritional habits. Although, in real clinical practice, that difference was not large enough to be statistically significant. Analysing BMI z-score, only two studies had the necessary information for the meta-analysis and showed no significant effect of gamification in this outcome. The forest plot and the risk of bias of each study are shown in Figures 2 and 3.

![Figure 2. Forest plot for nutritional knowledge.](image-url)
4. Discussion

To our knowledge, this is the first systematic review and meta-analysis that analyses the benefits of interventions based on the improvement of nutritional habits, knowledge, and changes in body composition in children and adolescents.

Game-based interventions showed improvements in the selection of healthy food groups within this population. As indicated in other studies, the consumption of fruits and vegetables increased [50–55]. Although other studies also found positive effects in knowledge about food groups, these were not reflected in an increase in the intake of this food group [53,56].

Knowledge about the five macronutrient groups also increased, as noted by other authors, although without maintained effects [57]. Other studies after online game interventions in nutritional programs showed improvements in calcium and vitamin D intake [58]. In addition, the frequency and quantity of sugar-sweetened beverage intake were also reduced [59]; while water intake, as corroborated by other studies, did not improve [59].

The gamification of nutrition can lead to improvements in dietary behaviour among adolescents in the short term [60]. Some studies that used card games found a 23.1% reduction in the number of students who did not eat breakfast, maintaining this habit up to 3 months later [61]. Others even found an improvement in adherence to the Mediterranean diet [54].

Several studies showed that gamification was effective in teaching nutrition and weight management knowledge, as well as in the intention to follow a healthy diet [62,63]. However, in this study, there were few articles that analysed changes in body composition, although the results found showed benefits in waist circumference and BMI. Similar studies conducted in children with obesity and pre-type II diabetes after mobile application interventions found improvements in BMI, waist circumference, and percentage of body fat maintained over time [64], and even in adults they found improved weight, BMI, fat mass, waist circumference, and cholesterol [63].

The meta-analysis showed a higher nutritional knowledge score after the intervention, as pointed out by other authors [65–67] and that the psychoeducational multimedia games had the potential to substantially change dietary behaviour [68].

Participants preferred to select healthier foods after playing [66]. At these ages, game-based interventions could exert a very positive influence in improving health. Through gamification, improvements have been made in sexual education [13] and smoking habits [69]. In addition, these strategies have also shown benefits in teaching processes in students of different educational levels [10,70].

Gamification was a useful method for improving health habits. The gamification process gives participants the possibility to learn and face the challenge through a different and exciting process that allows them to increase the degree of commitment [8]. In addition, motivation increases thanks to obtaining prizes and rewards [71,72]. All of this improved self-efficacy to select healthy foods and adherence to healthy lifestyles [73].

According to current international standards, the child and adolescent population eat insufficient fruit and vegetables and a lot of processed foods with added sugars [74]. The healthy eating habits that are acquired in childhood are maintained in adulthood, so it is
essential to promote an adequate intake. Given that more traditional health interventions have limited success, health policies could focus on the implementation of gamification projects in the school environment.

Limitations

This study has several limitations. First, although all studies use gamification as an intervention, the great variability in the duration of the intervention and minutes of play may influence the heterogeneity of the results. On the other hand, the interventions were relatively short in time. Furthermore, the sample size of the clinical trials was small and the monitoring of the effect of the intervention over time was little studied. Finally, it was not possible to perform a meta-analysis about important outcomes such as fruit/vegetable intake, due to the heterogeneity in the units of measurement and presentation of the studies’ data.

Future research would be necessary to analyse the improvement in all food groups by age, as well as the changes in body parameters. Furthermore, more clinical trials would be necessary to determine the lasting effects of the enhancement over time.

5. Conclusions

Gamification was a positive influence on dietary behaviour and nutritional knowledge. The choice of food groups improved, highlighting an increase in the consumption of fruit and vegetables. Furthermore, the results of the meta-analysis showed an increase in the level of nutritional knowledge, but a significant effect of gamification was not found for body mass index z-score. Game-based interventions could be very helpful in promoting healthy habits. Promotion of the development of effective educational tools to support children in nutrition learning is necessary in order to avoid and prevent chronic diseases related to nutrition from childhood.

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