

Digital-based nutrition education on nutrition knowledge and behaviors in adolescents: A systematic review

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Abstract. Adolescence signifies a transition period from childhood to adulthood marked by various changes, including nutrition behaviors. Nutrition behaviors established during this time often persist into adulthood, influencing long-term nutritional intake and status. Fulfillment of nutritional needs is an absolute for adolescents and poor nutrition behaviors can cause nutritional problems in adolescents. Nutrition education is one way to improve the nutrition knowledge and behaviors in adolescents. The advancement of technology gives rise to new media, one of which is digital media. Digital media such as mobile apps, podcasts, social media, and video games are shown to be effective media in nutrition education for improving people's nutritional knowledge and behaviors, including in adolescents. This PRISMA review aimed to identify and synthesize all related studies to assess the effectiveness of digital-based nutrition education in adolescents' nutrition knowledge and behaviors. All studies reported some positive outcomes on nutrition knowledge and behaviors in adolescents. In the future, a randomized controlled study with a longer duration is recommended for digital-based nutrition education.

1 Introduction

Adolescence signifies a transition period from childhood to adulthood marked by various changes such as exploring lifestyle choices and independence, including changes in nutrition behavior [1]. Nutrition behavior developed during adolescence often carries over into adulthood, influencing long-term nutritional intake and status [2]. The fulfillment of nutritional needs is an absolute necessity because adolescence is a critical and important period characterized by a significant growth spurt [3]. Because of the crucial role of nutritional intake in growth and development during this critical period, poor nutrition behaviors have the potential to result in nutritional problems in adolescents [4–7]. Therefore, interventions are needed to combat those problems in adolescents, one of which is through nutrition education.

Nutrition education is one way to improve nutrition knowledge and nutrition behaviors in adolescents. Dozens of studies have been carried out that focused on the prevention and

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handling of nutritional problems from an early age, namely in adolescents, through dietary and lifestyle changes by improving nutrition knowledge and behaviors [8,9]. Thus, nutrition education is needed to change and improve poor behavior in adolescents. There are various strategies for nutrition education, such as the use of educational media. The advancement of technology has given rise to new educational media that can be used in nutrition education, including digital-based educational media.

Digital media can be defined as mediums of digitized content that incorporate multiple media elements such as text, visuals, sound, video, and animation through electronic devices [10]. Thanks to the continuous evolution of technology, we can find various forms of digital media such as animation videos, digital apps, podcasts, social media, video games, and many more. In the past decade, the exponential growth of information and communication technologies has birthed new forms of digital media, initiating a shift in how nutrition and health information are being accessed [11]. As digital media has become an integral part of daily human life, researchers and educators started to use it as an educational tool in nutrition education [12]. Digital-based educational media is on the rise and starting to be used in nutrition education to improve people's nutrition knowledge and behaviors, including adolescents [13].

In the present day, adolescents are often called digital natives, which refers to the generation that lives in the digital era thus making them familiar with and enjoy using digital media [10]. The usage of digital-based media in nutrition education can be a promising strategy to entice adolescents and successfully expose them to good nutrition knowledge and practice. As a result, digital-based nutrition education can improve their nutrition behavior in the end. This systematic review aimed to identify and synthesize numerous studies to assess comprehensively the effectiveness of digital-based nutrition education in adolescents' nutrition knowledge and behaviors. This study addressed the following research question: What is the effectiveness of digital-based nutrition education interventions in improving adolescents' nutrition knowledge and behaviors?

2 Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) method was used in this review [14].

2.1 Data search and search strategy

Six databases were used for the article search: BMC, Google Scholar, Liebert Open Access, MDPI, PubMed, and Science Direct. The article search keywords were based on the Boolean operators “AND” and “OR” for the population (‘adolescents’, ‘teenager’), digital-based intervention (‘digital’, ‘nutrition education’, ‘app’, ‘social media’, ‘web’, ‘video’, ‘game’) and outcome (‘knowledge’, ‘eating practice’, ‘eating habit’ ‘nutrition behavior’).

2.2 Eligibility criteria

The inclusion criteria were articles published between 2013 and 2023. These included quantitative studies on digital-based nutrition education aimed mainly at improving nutrition knowledge and behaviors in adolescents aged 10-19 years old, available in full-text, and designed as an intervention study. The exclusion criteria were articles published only as abstracts, closed-access, literature review studies, and articles in languages other than English and Indonesian.

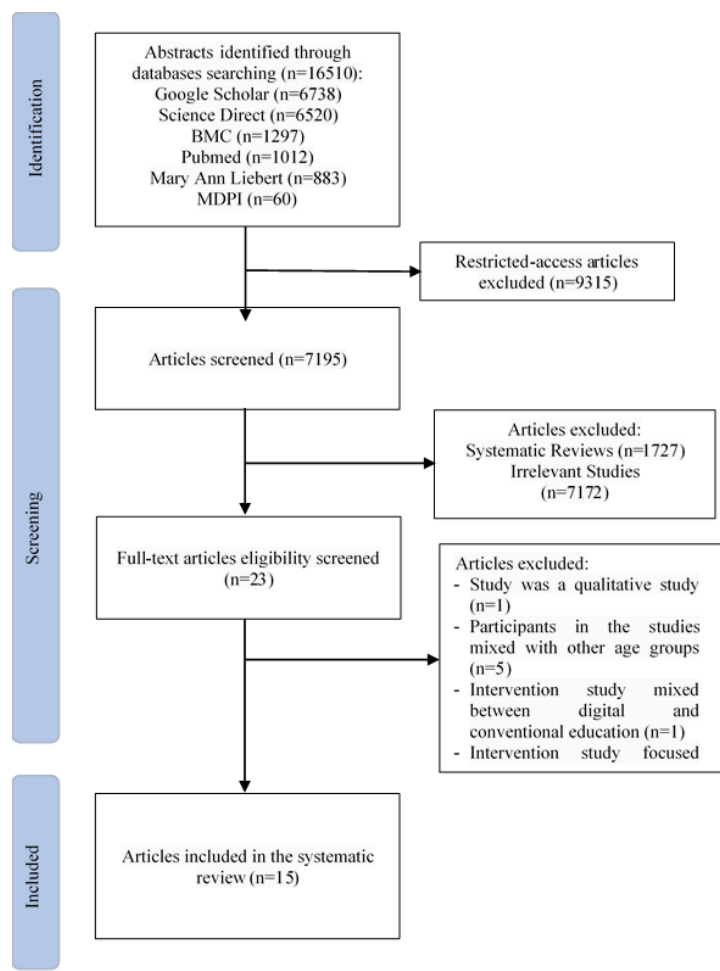


Fig. 1. PRISMA flowchart of article selection

2.3 Data synthesis and analysis

The data synthesis method used in this study was a descriptive and narrative data synthesis. Narrative data synthesis can be used as an alternative method in the systematic review of quantitative data where statistical synthesis is not possible [15]. The variables that were included and tabulated in this study were based on the PICO (Population, Intervention, Comparison, Outcome) method in order to get clear and detailed information from the included studies [16]. We extracted and summarized all of the included studies’ characteristics, intervention information, and outcomes of the studies.

3 Results and discussion

3.1 Details of included studies

The search across six electronic databases generated 16510 articles based on predetermined keywords. Out of 16510 articles found in the databases, 9315 restricted-access articles were

excluded. After applying inclusion and exclusion criteria, 1727 systematic review articles were excluded, and 7172 other irrelevant studies were also excluded. Out of 23 full-text articles from the final screening, 8 articles were manually excluded based on the inclusion criteria. Finally, 15 articles were selected and included in this study, as presented in Figure 1. The characteristics and results of the selected articles are presented in Table 1.

3.2 Characteristics of included studies

As shown in Table 1, all 15 studies were conducted in multiple countries across the world, with a predominant focus on Indonesia, followed by other locations like Iran, Italy, Saudi Arabia, Spain, Brazil, Malaysia, the United States, and the Netherlands. Six studies were from Indonesia, [17–22] 2 from the United States [23,24], and one each from Brazil [25], Iran [26], Italy [27], Malaysia [28], Netherlands [29], Saudi Arabia [1], Spain [30]. The studies implemented various research designs, such as randomized controlled trials (RCTs), pre-posttest control designs, and quasi-experimental designs, with the latter constituting the majority in this review. Four studies were randomized trials [1,23,25,26], 7 studies were quasi-experimental trials with control group designs [17–22,28], 3 studies were pre-posttest control trials [24,29,30], and 1 study was single group pre-posttest trial [27].

The majority of studies (10 out of 15) investigated the impact on nutrition knowledge [17–22,25–28], while the remaining five examined nutrition behaviors without nutrition knowledge [23,24,29,30]. The duration of interventions in the included studies also varied from brief sessions lasting a few days [29], while others conducted for as long as 14 weeks. Next, all of the studies comprise multiple forms of digital-based nutrition education, including 7 game-based [19,23–27,29], 3 mobile app-based [1,18,30], 2 social media-based [21,28], one podcast-based [17], one animation video-based [22], and 1 both game and social media-based nutrition education [20]. The majority of the interventions in this study were game-based nutrition education, which is not incidental, as adolescents are known for their engagement and hobby of playing video games [31]. Adolescents are a group that enjoys playing video games as a hobby and for entertainment. Data from the Entertainment Software Association (ESA) survey indicates that adolescents between the ages of 12 and 18 make up 40% of video game users [32].

3.3 Digital-based nutrition education on nutrition knowledge

All of the studies that examined the impact on adolescents' nutrition knowledge showed a significant increase after the intervention [17–22,25–28]. Eight studies included a control group [17,19,21,22,25,26,28,29] and some showed a significant difference between the groups with the intervention group having a higher knowledge average score [17,19–21,26]. All studies, regardless of the intervention duration, increased the adolescents' nutrition knowledge. Nutrition knowledge is one of the most important aspects because it is linked with nutrition behavior. Some studies showed that good nutrition knowledge is associated with optimum nutritional behaviors, encouraging people to make healthy food choices and adopt healthy eating practices [33].

Based on the Knowledge, Attitude, and Practice (KAP) Theory, knowledge is one of the key components to achieving behavioral change in an individual. In KAP Theory, an individual's behavioral change is achieved through the acquisition of the right knowledge, good attitude formation, and the adoption of practices in successive stages. In adolescents, nutrition knowledge combined with nutrition attitude and practice may provide cognitive understanding, and help form beliefs and attitudes, and thus promote change in their nutrition behavior.

Table 1. Summary of selected studies

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
1	Ghadam et al., 2023 [26] Iran	Digital game (Video game)	Randomized controlled trials study	10-19 y, n=160 adolescents (IG=80, CG=80)	14 weeks, seven game stages each two weeks	The impact of digital game-based nutrition education on knowledge, attitude, practice, and iron-deficient anemia markers	Yes. CG was given a PowerPoint presentation and pamphlets	Knowledge: 56.16±3.98 (IG) vs 50.57±6.95 (CG)= 0.987* Practice= 34.6±4.05 (IG) vs 31.06±4.81 (CG) = 0.807*	There was a significant increase of anemia-related KAP in the intervention group(IG), and there was a significant difference between IG and the control group (CG) (p<0.05). The intervention group has higher KAP scores, Hb, ferritin, and transferrin compared to CG
2	Shatwan et al., 2023 [1] Saudi Arabia	MyPlate App (Mobile app)	Randomized intervention study	13-18 y, n=104 adolescents (IG=55, CG=49)	6 weeks	The effects of the MyPlate smartphone app on fruit and vegetable consumption and BMI	Yes. No media/education was given to CG	Fruit intake score: 1.70±1.11 (IG) vs 1.64±0.98(CG) = 0.057* Vegetable's intake score: 1.43±1.03 (IG) vs 1.55±0.90 (CG)= 0.124*	There was an increase in fruit intake in both groups, but only the control group showed a statistically significant increase (p<0.05)
3	Adlu & Fayasari, 2023 [17] Indonesia	Bincangizi (Podcast)	Quasi experimental study with control group design	15-18 y, n=68 female adolescents (IG=33, CG=34)	2 weeks, two podcast per week	The effect of podcast audio-based nutrition education about anemia on knowledge, attitude	Yes. CG was given a flyer	Knowledge score: 88.71±12.51 (IG) vs 80.24±13.95 (CG) = 0.639*	There was a significant increase in nutrition knowledge on IG and a significant difference in knowledge between both groups (p<0.05)

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
									Participants agreed that the podcast were a good aid to learning about the nutrition subject
4	Sari et al., 2022 [18] Indonesia	WANTER App (Mobile app)	Quasi experimental study with a pre–posttest design	15-18 y female adolescents, n=277 (IG=162 ,CG=115)	3 months	The effect of the WANTER App on anemia-related nutrition KAP	Yes. CG was given a booklet	Insufficient Data	- There was a significant increase in nutrition knowledge and attitude in both groups ($p<0.05$), but there was no significant difference between both groups after the intervention ($p<0.05$) - There was no significant increase or difference in nutrition practice in and between both groups ($p>0.05$)
5	Merino-Godoy et al., 2022 [30] Spain	Healthy Jeart App (Mobile app)	Pre-posttest controlled experimental study	11-18 y, n=89 adolescents (IG=23. CG=36)	Unspecified short-period intervention	The effect of the Healthy Jeart mobile app on nutritional, physical activity, and positive, healthy habits	Yes. CG was given a class-based intervention	Energy drink consumption: −0.001 (IG) and 0.6 (CG)** Soft drinks and other drinks that do not contain sugar: −0.076 (IG) and −0.338 (CG)**	- There was a significant difference in weekly consumption of energy drinks and, soft drinks, and other drinks that do not contain sugar in CG ($p<0.05$) - There was no significant difference in nutritional habits between IG and CG ($p>0.05$)
6	Wati et al., 2021 [19] Indonesia	Isi Piringku Online	Quasi experimental study with pre-	17-18 y, n=70 adolescents	4 weeks, once per week	The effect of Isi Piringku digital game-based nutrition	Yes. No media/education was given to CG	Knowledge: 32.8±0.38 (IG) vs	There was a significant increase in nutrition knowledge in both groups, and a significant difference between the groups,

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
		(Web video game)	post control group design	(IG=35, CG=35)		education on nutrition knowledge and fiber intake		27.4±2.18= 0.328*	with the IG demonstrating a higher average of nutrition knowledge ($p<0.05$). There was no significant increase and difference in fiber intake in and between both groups ($p>0.05$)
7	Risti et al., 2021 [20] Indonesia	Whats App and online game	Quasi experiment with two group pre-posttest design	15-17 y, n=64 adolescents (WA group=32 with WA, Other group=32)	Unspecified intervention duration	The effectiveness of online social media-based nutrition education on nutrition knowledge and healthy food choices	No. But there was another IG that gave a lecture and online game	Knowledge: 62.03±6.67 (IG1) vs 69.80±16.66 (IG2)=0.612* Healthy food choices: 122.78±25.99 (IG1) vs 111.71±7.38 (IG2)=0.579*	There was a significant difference in nutrition knowledge and healthy food choices between both groups ($p<0.05$). the WA group has a higher average score of healthy food choices (122.78) but lower nutrition knowledge (62.03)
8	Yasira Rusdi & Auliya Rahmy, 2021 [21] Indonesia	Instagram and Whats App (Social media)	Quasi experimental pre-posttest with control group design	14-17 y, n=60 female adolescents (IG=30, CG=30)	18 days intervention, once per 2 days of Instagram posts	The effect of Instagram-based nutrition education on knowledge, attitude, balanced nutrition practice,	Yes. CG was given WhatsApp education	Knowledge: 15.37±1.73 (IG) vs 13.47±2.36 (CG)=0.640*	- There was a significant increase and difference in nutrition knowledge in both groups ($p<0.05$). The intervention group has higher average nutrition knowledge (15.37) compared to CG(13.47) - No significant increase and difference in practice after interventions in the IG and CG. There was no significant

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
									difference between both groups ($p>0.05$).
9	Jefrydin et al., 2020 [28] Malaysia	Info-Nutriten Instagram (Social media)	Quasi experimental pre-posttest with control group design	13-14 y, n=144 adolescents (IG=76, CG=68)	12 weeks intervention, once per week of Instagram posts	The effect and acceptance of Instagram-based nutrition education on anthropometric measures, nutrition knowledge, KAP on nutrition labels, acceptance of the intervention	Yes. No media/education was given to CG	Insufficient Data	- There was an increase in knowledge, attitude, and practice (KAP) in the group after the intervention; IG showed slightly better scores than CG in all of the variables - The intervention program had significant effects on the participants' attitudes and practices on nutrition labels. There was an improvement in their understanding and use of nutrition labels after intervention in IG. - The majority of the participants in IG reported positive acceptance towards the intervention (92.7%), and the media was interesting and easy to understand (95.6%)
10	(Chagas et al., 2020 [25]) Brazil	Rango Cards Digital Game (Video game)	Cluster randomized controlled trial with control group design	13-16 y adolescents, n=570 (IG=222, CG=348)	7-17 days,	The impact of digital-based nutrition education on food consumption, nutrition knowledge, self-	Yes. No media/education was given to CG	Insufficient Data	- IG showed increased knowledge of the effects of fruit and vegetable consumption - Improved self-efficacy in the adoption of healthy eating practices in IG.

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
						efficacy, dietary perceptions, dietary practices			Significant reductions were observed in the IG compared with the CG for the habit of eating while watching TV or studying and having meals at fast food restaurants ($p<0.05$)
11	Masitah et al., 2020 [22] Indonesia	Animation video	Quasi-experimental with non-equivalent control group design	16-17 y, n=84 adolescents (IG=42, CG=42)	1 month, one video each week	The effectiveness of animation video-based nutrition education on nutrition knowledge	Yes. No media/education was given to CG	Insufficient Data	There was a significant increase in nutrition knowledge in IG after the intervention (20.14 vs 15.79, $p<0.05$)
12	Baranowski et al., 2019 [23] United States	Escape from Diab and Nanos warm (Video game)	Randomized controlled trials study with two-group (treatment vs. waitlist control)	10-12 y, n=200 obese adolescents (IG=96, CG=145)	3 month, nine sessions with 60 minutes playing duration per session	The efficacy and impact of Diab and Nano on the primary outcome (fast insulin) and targeted behaviors (eating behaviors, physical activity)	Yes. Given intervention at the end of 5-month post-baseline	Insufficient Data	No significant differences were detected in any of the tested outcome variables
13	Hermans et al., 2018 [29]	Feed the Alien!	Experimental design	10-13 y, n=108 adolescents	2 days, children in both groups	The impact of video game-based nutrition education on	Yes. CG was an active control	Energy-dense food intake at two-week	The Alien Health Game increased certain aspects of children's nutritional knowledge in the short term, but two short

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
	Netherlands	(Video game)	with a single between-subjects factor (experimental condition vs. active control condition)	(IG=58, CG=50)	played twice for 30 minutes	nutrition knowledge and food intake	group and was given the web-based Super Shopper video game	follow-up: $\eta^2_{\text{partial}}=0.442^{***}$	bouts of gameplay do not induce longer-term behavioral effects. In contrast, it was found that children consumed more energy-dense foods at the follow-up measurement compared to the first measurement
14	Marchetti et al., 2015 [27] Italy	Gustavo In Gnam's Planet (Video game)	Single pre-post pilot experimental study	14-18 y, n=83 high schools adolescents	1 week, IG played the game for at least half an hour per day	Pilot video-game-based intervention on nutrition knowledge (diet knowledge) and enhance healthy food consumption (behavior change, eating behavior)	No Control	Knowledge: 70.0±9.2 (pre) vs 71.3±10.0 (post)= 1.625****	- Knowledge of healthy foods showed significantly higher scores posttest compared to pretest (71.3 vs. 70.0; $P<0.05$). - Improvements in healthy eating habits were such as increased weekly consumption of white meat ($p=0.01$), eggs ($p=0.01$), and legumes ($p=0.03$), and a decreased frequency of sugar-containing packaged snacks ($p=0.009$). 76.6% subjects judged "Gustavo" easy to use and 50% found the game interesting.
15	Majumdar et al., 2013 [24]	Creature-101 (Video game)	Pre-post-intervention with control	11-13 y, n=590 adolescents	1 month, nine sessions with 30	To evaluate the efficacy of "Creature-101" video game on	Yes. CG was an active control	Processed Snacks Frequency: 1.79±1.24 (IG)	Decreases in frequency and amount of consumption of sweetened beverages and

No	References	Media	Intervention Description					Effect Size	Results
			Study Design	Participants	Duration and Frequency	Study Objectives	Control		
	United States		group design	(IG=359 , CG=172)	minutes each session	eating behavior and PA	group and was given the “Whyville” online game	vs 2.21±1.36 (CG)= 0.322* Processed Snacks Amount: 1.67±0.65 (IG) vs 1.89±0.69 (CG)= 0.328*	processed snacks compared with the controls

Notes:

IG – Intervention Group

CG – Control Group

RCT – Randomized Controlled Trial KAP – Knowledge, Attitude, Practice

FV – Fruits and Vegetables

PA – Physical Activity

BMI – Body Mass Index

Insufficient Data: No data available or not enough data to calculate effect size

*=Cohen’s d effect size measurement

**=Rank Biserial Correlation measurement

***=Partial eta squared measurement

****=Cohen’s pre-post d effect size measurement

Good nutrition knowledge regarding the importance of healthy eating in adolescents may encourage them to have a positive attitude and their willingness to change, making them invoke behavioral change to have better eating habits. Although barriers and enablers may affect these components, nutrition knowledge remains a critical factor in the process of behavioral change [34]. Thus, when conducting nutrition education, one should also focus on nutrition knowledge as the targeted outcome because in order to change a person's nutrition behavior, their nutrition knowledge should also improve as well to enable them to behavioral change [35].

3.4 Digital-based nutrition education on nutrition behaviors

We observe that 6 out of 15 studies reported improved adolescents' nutrition behaviors after the intervention, including increased fruit intake [1], reduced consumption of sweetened and processed beverages and snacks [24], and improved dietary practices such as anemia-related nutrition practice [26], healthy food choices and eating habits [20,27], nutrition label use [28], eating habits while watching or studying [25], and reduced fast food consumption [25]. The majority of the studies above that showed nutrition behavior improvement had longer intervention duration. One game-based nutrition education with a randomized design and long intervention duration (14 weeks) showed a significant impact on improving anaemia-related KAP and even the biological markers [26]. The intervention group in the study showed higher KAP scores, Hb level, ferritin, and transferrin level compared to the control group.

However, despite the long intervention duration can contribute to significantly improved behaviors, there was one study in this review that showed a significant behavioral change in adolescents [23]. Game-based nutrition education "Escape from Diab and Nanoswarm" with 3 months of intervention duration did not have a significant effect on improving eating behaviors, physical activity, and fast insulin level of the participants. Several explanations may explain the lack of behavioral improvement from the study such as the lack of necessary elements in the game that failed to influence the adolescents' behaviors to shifting gaming preferences of genre and adolescents' interests towards video game. Nevertheless, the author stated that experimenting with adding several engaging game mechanics and the usage of behavioral change theories can enhance the effectiveness of game-based nutrition education in the future.

Shorter intervention studies often did not achieve behavioral change among participants [19,21,29]. For example, the "Feed the Alien!" video game intervention, which only had a 2-day intervention duration, only showed an increase in nutrition knowledge but no behavioral change after the intervention. Another study, "Isi Piringku" video game intervention, with a 4-week duration, also only showed a significant improvement in nutrition knowledge, with no significant increase in fiber intake. However, the "Gustavo in Gnam's Planet" intervention showed an increased knowledge and improvement of healthy eating habits with only 1 week of intervention duration. The usage of several behavioral change theories during the development of "Gustavo" is said to be one of the main reasons why the intervention successfully improved the behaviors of the participants. The application of behavioral change theory as a framework in nutrition education is widely utilized and has been shown to help in successfully improving participant's behaviors [36].

Digital-based nutrition education appeared to be a promising strategy to improve adolescents' knowledge and behaviors. Analyzing the effectiveness of digital-based nutrition educations in improving the nutrition knowledge and behaviors was the main objective of this study. As we verified, they improve the adolescents' nutrition knowledge and some showed improving the adolescents' nutrition behaviors as well. However, further education strategies are needed to successfully improve adolescents' nutrition behavior. As stated

above, longer intervention duration and follow-up sections can be applied in nutrition education to maintain and strengthen adolescents' knowledge and adherence, thus encouraging them to apply what they learned in their nutrition behavior [37].

Other strategies to improve the effectiveness of nutrition education include family and school involvement, as they may serve as important moderators in the outcome of the intervention. During early childhood to adolescence, caregivers, particularly parents, still have a significant influence over the adolescents' lives. Food choices, availability, eating habits, and practice are some of the behaviors that are primarily learned and influenced in the family at early age [38]. Correspondingly, schools' involvement may also increase the effectiveness of digital-based nutrition education when conducted in schools. Teachers can participate and act as supervisors during interventions thus increasing the compliance and engagement of the adolescents. Incorporating nutrition education during classes or school's activities may improve compliance as well. Additionally, when both teachers and parents are involved in nutrition education, their activity can be supervised by both of them respectively and strengthen the compliance even further. Thus, school and family reinforcement can be conducted during nutrition education as the general consensus to achieve the best results [39].

Currently, the development of digital-based nutrition education increasingly incorporates the use of "gamification". Gamification can be defined as the incorporation of game design elements in non-game contexts. This approach integrates aspects of video game mechanics into the interventions' design. For example, adding a leaderboard or scoreboard is considered gamification to invoke a sense of positive social relationship such as healthy competition among the respondents. Adding a reward system during the intervention is also another form of gamification that helps adolescents to be more involved [40]. Providing incentives such as pocket money, school equipment, or course credit if they finish a task can further motivate adolescents and stimulate behavioral change. For adolescents, gamification in digital-based nutrition education may affect and encourage them to promote nutrition knowledge acquisition and affect their behaviors [41]. These strategies are recommended for future research in digital-based nutrition education on adolescents and promote behavioral change in their nutrition behavior.

3.5 The acceptability of digital-based nutrition education

Several studies also explored acceptability of the digital-based nutrition education on adolescents. In podcast-based nutrition education [17], participants agreed that the podcasts provided a good summary and learning aid on the topic being addressed. One game-based nutrition education showed high acceptability by the participants as well [27]. In the Instagram social media-based nutrition education, more than 90% of the participants gave positive acceptance towards the intervention [28]. This approach aligns with how people access information in today's advancing society and technology landscape, including adolescence [13]. Adolescents today are often called digital natives, as they are grown up and exposed to many forms of digital media from a very early age. They are familiar with and enjoy using digital media such as mobile apps, social media, video games, and many more. The use of digital-based media in nutrition education is very important to entice adolescents and stimulate them to improve their nutrition behavior by delivering essential and good nutrition knowledge and messages through the media that they like [10].

4 Conclusion

The use of digital-based media in nutrition education showed a positive impact in improving the nutrition knowledge and nutrition behaviors of adolescents. This systematic review showed that digital-based nutrition education is a promising approach to successfully

providing information and knowledge about nutrition and improving behaviors for the young generation. In the future, digital-based nutrition education should implement a randomized-controlled design and longer interventions to significantly improve adolescents' nutrition knowledge and behaviors further. Integrating family and school involvement, utilizing behavioral change theories as the foundation, and incorporating gamification elements during the intervention can also enhance the intervention's effectiveness in successfully improving adolescents' knowledge and behaviors. This systematic review had some limitations, including the lack of a detailed meta-analysis due to the type of data reporting in the study for which the effect size could not be calculated. Despite its limitations, the findings of this review can offers useful information in developing future nutrition education for adolescents.

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