Design Features Associated with User Engagement in Digital Games for Healthy Lifestyle Promotion in Youth: A Systematic Review of Qualitative and Quantitative Studies

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Abstract

User engagement in digital (serious) games may be important to increase their effectiveness. Insights into how to create engaging games for healthy lifestyle promotion are needed, as despite their potential, not all digital (serious) games are highly engaging. This study systematically reviewed game features that were associated with higher user engagement among youth. A systematic search was conducted in PubMed, Web of Science, CINAHL, and PsycARTICLES databases. Qualitative and quantitative studies were included, if they documented game features associated with youth engagement. Coding of game features was performed using the mechanics-dynamics-aesthetics (MDA) framework. A total of 60 studies met the inclusion criteria and were included in the registered systematic review (No. CRD42018099487). Results showed that various game features were associated with user engagement in digital (serious) games: an attractive storyline, adaptable to gender and age, including diverse (antagonist) characters the user may identify with, high-end realistic graphics, well-defined instructions, which can be skipped, in combination with clear feedback and a balance of educational and fun content. This review underpinned the relevance of investigating engaging game features specifically for youth, as deviations were found with characteristics that are engaging for other populations.

Keywords: Engagement, Serious game, Health, Youth, Systematic review

Introduction

YOUTH HEALTHY LIFESTYLE PROMOTION is important to prevent the risk of developing noncommunicable diseases at a later age, including diabetes type 2, certain forms of cancer, and cardiovascular diseases.^{1–3} Healthy lifestyle behaviors are moreover associated with a higher sense of well-being among youth.⁴ A healthy lifestyle covers a range of behaviors, including exercise/physical activity; a healthy diet; health responsibility/maintenance (e.g., regular doctor visits); social behavior; and mental health, including stress management and self-actualization.^{5–8} Around two-thirds of children and adolescents show more than one unhealthy lifestyle behavior.⁶ Since established lifestyle patterns in childhood or adolescence often track into adulthood,⁹ interventions that address healthy lifestyle behaviors among youth are needed.¹⁰

Many systematic reviews and meta-analyses have underscored the potential of serious digital games to promote healthy lifestyle behaviors among youth and adults.^{8,11–16} Serious digital games are a form of organized play that contain a

challenge, rules, rewards or feedback, and are intended to be both entertaining and educational.¹⁷ To be effective, it is important that users experience a sufficient degree of engagement with the game,¹⁸ otherwise known as effective engagement, or the sufficiently subjective engagement and behavior to achieve desired and positive outcomes.¹⁸ User engagement in games is defined as the involvement and motivation of the player in game play,¹⁹ and can be conceptualized in terms of subjective engagement or experience (e.g., attention, interest, and affect) and behavior (e.g., usage).²⁰ Higher user engagement in digital (serious) games was associated with continued play, increased attention, and potentially increased game effects.^{21–23}

As such, digital games may overcome motivational barriers related to low usage, early dropout, or even nonusage, currently faced in many health promotion programs.^{24–27} To the best of our knowledge, few studies have, however, examined the association between game engagement and effectiveness. The available research confirmed that higher engagement was associated with higher effectiveness in healthy lifestyle promotion among adolescents and young adults.^{22,28,29}

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Given the potential crucial role of user engagement for game effectiveness, it is important to know how to design games that can yield higher user engagement. Research has demonstrated that playing against a human-controlled opponent, being technology advanced, including sound or music,²¹ suspense,²¹ a story,^{21,30} positive reinforcement,²¹ a buddy,³¹ feedback, and controller use,³² competitive or co-operative play³³ was associated with higher game engagement. However, these findings stem from studies among adults or broad target groups in terms of age, and did not specifically address games for healthy lifestyle promotion or studies among youth.

To date, studies investigating game features (i.e., prominent game elements that define what a game entails) of engagement for digital games in healthy lifestyle promotion among youth are scarce.^{34,35} Investigating features separately for this age group (6–18 years) is, however, needed, since user engagement is thought to differ between youth and adults due to cognitive differences.²⁰ The aim of this study was to conduct a systematic review on game features associated with youth's subjective engagement with digital (serious) games for healthy lifestyle promotion.

Materials and Methods

The research protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) at www.crd.york.ac.uk/prospéro (No. CRD42018099487). Reporting complied with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement³⁶ (Supplementary Table S1).

Search strategy and eligibility

Four electronic bibliographic databases were searched for relevant articles: PubMed (°1966), Web of Science (°1926), CINAHL (°1937), and PsycARTICLES (°1894). The search was limited to articles published between January 2000 and end of November 2018 and was conducted using keywords listed in Table 1. Both the strategy and keywords are listed in Table 1 and are partly based on an earlier meta-analysis on serious games and health.⁸ In addition, relevant studies were identified from bibliographies in relevant reviews.^{8,11,12,21,37–42}

For all qualifying articles, relevant studies were identified independently by screening titles and abstracts, by one researcher and one-third by a second researcher. Next, full texts were read independently to determine final eligibility, by one researcher and one-third by a second researcher. Qualitative or quantitative studies among 6–18-year olds investigating game features in relation to user engagement as subjective experience with a digital game for healthy lifestyle promotion were included. Table 1 lists full inclusion and exclusion criteria.

Data extraction and synthesis

Data extraction was completed by one reviewer (A.F.S.) and one-third ($n=19$) was checked by another reviewer (A.D.S.) for accuracy. The following information was extracted by both reviewers: game features associated with engagement (e.g., graphics), measure of engagement (e.g., fun), and health domain (e.g., physical activity). Features and engagement were used based on their descriptions in the

articles, and not based on coding based on classified categories. Disagreement regarding data extraction was resolved through discussion between reviewers (A.F.S. and A.D.S.). Inter-rater reliability was almost perfect ($\kappa=0.92$).⁴⁶ Descriptive information (e.g., authors, publication year, and health topic) is provided in Supplementary Table S2.

MDA framework, behavioral change techniques, and genre

Game features were coded with a coding frame based on the mechanics-dynamics-aesthetics (MDA) framework⁴⁷ (Supplementary Table S3), which describes key game elements that can influence experience. The framework is developed from a game-based learning theory in game design and is often used in game research. It contains three components: game mechanics, dynamics, and aesthetics (Table 2). Mechanics are the basic components of the game, such as rules, basic actions, and the data structure of the game (e.g., game controller). Dynamics are the runtime behavior of the game and focuses on the interactions with the player (e.g., feedback).

Game aesthetics are the emotional responses of the player when he/she interacts with the game (e.g., narrative). The framework added a taxonomy of eight types of aesthetics: (1) sensation: players experience something completely unfamiliar, their senses are triggered (e.g., graphics); (2) fantasy: players engage in an imaginary world (e.g., role playing); (3) narrative: players follow a story that drives the player to keep coming back (e.g., identification with characters); (4) challenge: players master a certain level that boosts replayability (e.g., side missions); (5) fellowship: players are part of a community, as in multiplayer games (e.g., competition); (6) discover: players explore the game world (e.g., quests); (7) expression: players create their own characters as avatar and can express themselves by their creativity (e.g., customization); and (8) submission: players engage in the game to past time and are not distracted by any constraints (e.g., enjoyment).

The coding frame was developed in consensus by two behavior scientists (A.D.S. and A.F.S.) and one external game developer. Features were coded as belonging to one single MDA component to which it fits best, although it is important to note that components are closely linked to each other.

Some elements related to behavior change techniques (BCTs) that did not fit the MDA framework. These were coded with a taxonomy of BCTs (e.g., personal goal setting).⁴⁸ In addition, game genre (i.e., category of games that relates to similar game play characteristics) is not part of the MDA framework, and was coded separately (e.g., adventure).⁴⁹

Engagement

A coding frame for engagement emerged from the individual studies' engagement construct and were categorized into five categories (i.e., engagement, affective engagement, perceived usability, interest, and immersion) based on dimensions from validated game engagement questionnaires^{20,50–52} (Table 3). After extracting the engagement dimension of the original study (e.g., acceptability), it was coded according to the five-category coding frame (e.g., perceived usability).

Whereas engagement refers to the overall assessment of engagement, affective engagement refers to measures of

TABLE 1. DETAILED SELECTION CRITERIA FOR INCLUSION AND EXCLUSION OF STUDIES IN THIS REVIEW

Search terms	(game* or exergame* or videogame* or “digital game*” or “serious game*” or “mobile game*” or “computer game*” or “online game*” or “web game*” or “smartphone game*”) and (“user engagement” or “user satisfaction” or engag* or enjoyment or immersion or flow or transportation or involvement or presence or attention or interest or affect or motivation or pleasure or adherence or attrition or “temporal dissociation” or preference or “perceived usefulness” or acceptability or experience or playability or usability) and health and (children or adolescen* or teen or pube* or youth or youngster* or younger or kid*)	
Criteria	Inclusion	Exclusion
Digital games	Definition: organized play having a set of rules by which to play and a goal, which created a challenge, provides feedback or showed outcomes, entailed interaction, and had a topic ⁴³ ; One or more digital game(s); Both serious games, with the aim of promoting health while also being fun, and commercial off-the-shelf games.	Multimedia programs with no interaction (e.g., only watching a video without a challenge); Board games or games that did not use digital technologies as the delivery media.
Designed for healthy lifestyle promotion	Definition of healthy lifestyle promotion: the ability to adapt and self-manage mental, social, and physical health ⁴⁴ ; Both health-protecting (reducing risk of illness) and health-promoting (increasing well-being and personal fulfillment) behaviors, using the dimensions of the Health-Promoting Lifestyle Profile Scale ⁷ ; Healthy diet, exercise/physical activity, social behavior, health responsibility/maintenance, and mental health promotion (including stress management and self-actualization). ^{7,8}	Games that only targeted an increased skill level, but no healthy lifestyle change (e.g., athletic performance); Which were only used in a therapeutic context and with no intent to create a lifestyle change (e.g., treatment support); Which were used for professional education.
Engagement as experience	Reported on subjective game engagement experience; Definition: subjective experience surpassing mere information on usage (immersion, flow, balance between challenge and skill, attention for the game, interest in the game, affect, stimulation, motivation, enjoyment, pleasure, presence, temporal dissociation, preference, perceived usefulness, and acceptability). ¹⁸	Only investigated behavioral forms of user engagement, such as usage or continued use ⁴⁵
Investigating a relation with features of user engagement	Only investigated a relationship between potential moderators or mediators as features of serious/commercial off-the-shelf digital game engagement and engagement outcomes	Only describe user engagement without any relation to potential moderators or mediators of engagement; Studies that reported on scale design to measure game engagement; Studies that reported on engagement for other aspects than the game (e.g., enjoyment of the targeted health behavior).
Target group	Only targeted youth (6–18 years old or mean age within age range); Described user engagement directly in this target group.	Games targeted or tested exclusively among younger children (<6 years of age), adults, elderly, or when mean age is not within age range of 6–18 years old; Only providing adult proxy reports of engagement, e.g., acceptance of games by children’s or adolescent’s parents.
Type of article	Original research articles, conference articles, and book chapters	Editorials, opinion articles, case studies, research protocols, design articles not including any user testing, systematic reviews or meta-analysis
Language	Published in English	Published in languages other than English

TABLE 2. MECHANICS-DYNAMICS-AESTHETICS FRAMEWORK, GENRE, AND BEHAVIORAL CHANGE TECHNIQUES

MDA	Definition	Examples
Mechanics	Basic components of the game, as rules, basic actions, and the data structure of the game	Game controller, device requirement, platform
Dynamics	Runtime behavior of the game and focus on the interactions with the player	Feedback, rewards, game goals
Aesthetics	Emotional responses and interactions of the player when he/she interacts with the game (e.g., enjoying to jump)	
	Taxonomy	
	1. sensation: experiencing something completely unfamiliar, which triggers their senses;	1. Graphics, sounds, and language
	2. fantasy: engaging in an imaginary world; not being able to be in real life;	2. Role playing
	3. narrative: following a story that drives the player to keep coming back;	3. Identification with characters
	4. challenge: mastering a certain level that boosts replayability;	4. Different levels or side missions
	5. fellowship: being part of a community, as in multiplayer games;	5. Competition, cooperation
	6. discovery: finding new things, exploring the game world;	6. Quests
	7. expression: ability of players to express own creativity in game;	7. Customization and making autonomous choices
	8. submission: engaging in the game to pass time and not being distracted by any constraints (not coded).	8. Enjoyment, engagement, flow in game (not coded)
Genre	Category of games that relates to similar game play characteristics	Action/adventure
BCT	Theory-based techniques for changing one or several psychological determinants of human behavior	Shaping knowledge, personal goal setting, and self-monitoring

The categories of the MDA framework were based on earlier reference,⁴⁷ and otherwise in collaboration with the game developer. BCT, behavior change technique; MDA, mechanics-dynamics-aesthetics.

the affective state only (e.g., enjoyment). Perceived usability refers to the user experience (e.g., acceptability), interest refers to the cognitive state (e.g., perceived relevance), and immersion refers to perceived state of being in the game (e.g., transportation). Measures of engagement included validated scales (e.g., electronic game use anxiety scale), quantitative scales (e.g., emoticons), or qualitative assessments of engagement in focus groups (e.g., preferences and acceptability).

Quality assessment

Two scoring systems assessed the studies' quality: the appraising tool of qualitative evidence⁵³ and Effective Public Health Practice Project assessment tool for quantitative

studies.⁵⁴ For the assessment of mixed-method studies, both tools were used. Quality assessment was not used as a basis for study exclusion, but to support result interpretation. All studies were coded on quality (A.F.S.) and a third was double coded (A.F.S. and F.J.H.D.), inter-rater reliability was almost perfect ($\kappa=0.96$).⁴⁶

Results

Description of included studies

Fifty-five articles that described 60 studies ($n=5$ mixed-method studies) on the relationship between game characteristics and subjective user engagement were included (Fig. 1). Most studies originated in North America (26/60) and targeted exercise/physical activity (34/60). Other studies addressed health responsibility/maintenance ($n=17$), healthy diet ($n=4$), mental health ($n=2$), and social support ($n=1$) (Table 4). There was a large diversity in engagement measures studied, with affective engagement ($n=23/60$) and perceived usability ($n=20/60$) studied most often (Table 5). The majority of studies used a qualitative design (36/60).

An overview of identified game features is listed in Figure 2. Features associated with engagement are summarized in Table 5. Both are ranked according to strength of association, from games features showing the highest associations with engagement to those with the weakest associations with engagement. Results are presented according to the MDA framework elements, genre, and BCTs.

More than half of qualitative studies (58%) showed good (18/36) or fair quality (3/36), whereas 42% showed poor (14/36) or very poor quality (1/36). Half of quantitative studies showed moderate (8/24) or strong (4/24) quality; the other half was of weak quality (12/24) (Supplementary Table S4).

TABLE 3. CODING FRAME FOR USER ENGAGEMENT

Engagement categories	Engagement measures
Engagement	Engagement measured as overall concept
Affective engagement (positive or negative)	Measures of anxiety, arousal, affect, enjoyment, fun, satisfaction, and liking
Perceived usability	Measures of experience (user friendliness), acceptability, usability, playability, and mobility
Interest	Measures of interest, preference, perceived relevance, importance, and motivation
Immersion	Measures of immersion, transportation, and self-presence

FIG. 1. Flow chart of included studies.

Weak quality in quantitative studies was mainly due to a nonexperimental study design, potential for selection bias, and lack of controlling for confounders. In qualitative studies, weak quality was especially due to weak type of data analyses, lack of description of ethics or researcher bias, and limited info on sampling or generalizability.

Aesthetic features

Challenge (23/60 studies). In general, users wanted manageable and easy-to-achieve challenges.^{55–59} Some challenges were experienced as too hard,^{60–64} especially by girls.⁶⁵ In active videogames, children and adolescents preferred low rather than high physical intensity.⁶⁶ Complex movements or a fast pace resulted in player frustration.⁶⁶ Youth generally preferred to have different levels of challenges,^{67–69} either by having several side missions,^{60,70,71} levels of increasing difficulty level,⁷² or difficulty level tailored by age.^{73,74} When a challenge was met, children experienced a sense of mastery, but they disliked having to keep trying unsuccessfully.⁷³ Unexpected traps and obstacles were considered to make a challenge even more fun.⁷⁵

Narrative (11/60) and character identification (17/60). Identification with characters was significantly associated with immersion.^{30,76} Youth preferred a high degree of realism and (cultural or body development related) similarity of the characters to themselves.^{30,63,75,77–79} A preference for

high realism did not preclude an interest in fantasy and other nonhuman characters, mainly as antagonists and especially among young children.^{80,81} Human characters were generally preferred as protagonists.^{80,81} Youth also mentioned transitional characters, who would change from being bad to good.⁸⁰ There was also a preference for a higher number of diverse characters in the game.^{58,60,70,71,82} Older adolescents preferred more complex characters with ambivalent personalities.⁸⁰ One study mentioned a preference for a fit between the characters and the health topic in the game.⁷⁴ Characters, however, seemed to be less important for engagement than the storyline,⁷⁷ which was considered as very important.^{60,67,77,83} Having a narrative in the game was preferred to a non-narrative game.⁸² Important aspects of the storyline were its originality,⁷⁷ especially among older youth⁷⁸; that it fits their personal life, in terms of both realism^{59,81,83} and their cognitive abilities⁷⁷; and that it has a sufficiently high pace.⁷⁸ A narrative that could facilitate transfer of the learned behavior to real life (e.g., conversations with parents and partners about sexual health) was appreciated.⁶⁹ Preferences for storylines included fight scenes, mainly among boys⁸²; conflicts (crime, catastrophe, and war); and professional skill development, mainly among girls.⁸¹

Sensation: graphics (13/60), music (8/60), and language (2/60). Graphics and animations, that is, digital representation

TABLE 4. OVERVIEW OF GAME FEATURES STUDIED IN PARTICULAR HEALTH DOMAIN

	<i>Exercise/ physical activity</i>	<i>Health responsibility/ maintenance</i>	<i>Healthy diet</i>	<i>Mental health promotion</i>	<i>Overall health</i>	<i>Social behavior</i>	<i>Total number of studies</i>
Aesthetics							
Challenge	13	5	3	2	0	0	23
Identification with characters	8	4	1	2	1	1	17
Graphics	8	3	0	1	0	1	13
Customization	5	3	1	1	1	1	12
Narrative	6	3	0	0	1	1	11
Music/sound	5	2	1	0	0	0	8
Competition	6	1	0	0	0	0	7
Cooperation	5	1	0	0	0	0	6
Creative freedom	5	1	0	0	0	0	6
Community	3	1	0	1	0	0	5
Language	1	0	0	1	0	0	2
Discovery	2	0	0	0	0	0	2
Fantasy	0	1	0	0	0	0	1
Dynamics							
Rewards	12	5	0	1	0	0	18
Feedback	7	2	0	0	0	0	9
Instruction	7	2	0	0	0	0	9
Time limits	2	4	0	0	0	0	6
Active vs. passive game play	5	0	0	0	0	0	5
Game goals	3	0	0	0	0	0	3
Mechanics							
Device and media requirement	7	3	0	0	0	0	10
Game controller	4	4	2	0	0	0	10
Genre	4	2	0	1	0	0	7
BCTs							
Shaping knowledge	2	7	1	0	1	0	11
Personal goal setting	1	1	0	0	0	0	2
Self-monitoring	1	1	0	0	0	0	2

of nontext information, were considered as very important by users,^{59,67,84} whereas animation, that is, appearance of motion created by displaying a series of still images in sequence, was less important.⁷⁷ Graphics were liked when showing high resolution,⁸⁵ three-dimensional,^{59,70,77} and realistic^{59,74,75,86}; having a cartoon look⁸⁶; colorful graphics⁷⁵; showing real

movement⁸²; or animation in the background.⁷⁵ In general, adolescents highly valued the integration of music and sounds.⁶⁴

Well-liked types of music and sounds were “spooky sounds,”⁶⁸ realistic sound effects that matched the challenge; which reflected their movement⁷⁵ and had several

Mechanics	Dynamics	Aesthetics	Behavioral change techniques & Genre
<ul style="list-style-type: none"> Mixed results on game controller Device and media requirements: multimedia and integration in environment 	<ul style="list-style-type: none"> Fair rewards linking to game outcomes Feedback related to game outcomes that is clear and easy to interpret Game goals that can be set by the player Time limit that is achievable Active versus passive gameplay choice 	<ul style="list-style-type: none"> Achievable challenges that increase in difficulty and are age-dependent Identification with characters, diversity of characters & avatar customization Realistic narrative tailored to age/gender preferences Three-dimensional, high resolution & realistic graphics Realistic sounds and music choice Social community, cooperative/competitive features, team composition Also: simple & appropriate language; role-playing; finding hints 	<ul style="list-style-type: none"> Balance of educational and fun content that is reliable and positively framed Personal goal-setting outside gameplay Self-monitoring own behavior Action/Adventure genre with different preferences for age and gender

FIG. 2. Features contributing to engagement in digital (serious) games among youth.

TABLE 5. OVERVIEW OF ESTABLISHED ASSOCIATIONS WITH ENGAGEMENT MEASURES

	<i>Affective engagement</i>	<i>Interest</i>	<i>Immersion</i>	<i>Perceived usability</i>	<i>Overall engagement</i>	<i>Total number of studies</i>
Aesthetics						
Challenge	4/8	3/4	1/1	6/8	1/2	15/23
Identification with characters	4/4 ^a	2/4	5/5 ^a	4/4	0/0	17/17
Graphics	2/2	2/3	1/1	6/6	1/1	12/13
Customization	2/2	2/5	2/2	3/3	0/0	9/12
Narrative	4/4	4/4	1/1	2/2	0/0	11/11
Music/sound	3/4	0/1	0/0	1/3	0/0	4/8
Competition	1/2	4/5	0/0	0/0	0/0	5/7
Cooperation	1/3	1/1	0/0	2/2	0/0	4/6
Creative freedom	1/1	2/3	0/0	2/2	0/0	5/6
Community	2/2	2/2	0/0	0/1	0/0	4/5
Language	0/0	1/1	1/1	0/0	0/0	2/2
Discovery	1/1	0/1	0/0	0/0	0/0	1/2
Fantasy	0/0	0/0	0/0	1/1	0/0	1/1
Dynamics						
Rewards	5/5	4/6	1/1	6/6	0/0	16/18
Feedback	3/3	1/1	0/0	4/5	0/0	8/9
Instruction	0/3	1/2	0/0	0/4	0/0	1/9
Time limits	1/1	0/0	0/0	2/5	0/0	3/6
Active vs. passive game play	2/4	1/1	0/0	0/0	0/0	3/5
Game goals	1/2	0/0	0/0	1/1	0/0	2/3
Mechanics						
Device and media requirement	1/1	2/2	0/0	4/4	0/1	8/10
Game controller	2/4	1/2	0/0	3/4	0/0	5/10
Genre	1/1	4/4	1/1	0/0	1/1	7/7
BCTs						
Shaping knowledge	2/2	3/3	0/0	6/6	0/0	11/11
Personal goal setting	0/0	2/2	0/0	0/0	0/0	2/2
Self-monitoring	0/0	1/2	0/0	0/0	0/0	1/2

Number of studies with an established association/number of studies in which this was investigated.

^aIn one study, affective engagement and immersion were measured jointly; we counted it as part of immersion.

music options.⁶⁰ Not well-liked types of music and sounds were a soundtrack,^{74,77} songs that did not change,^{84,87} and clicking sounds.⁷³ Language was mentioned as a feature that should not be inappropriate,⁷⁷ and not too simplistic.⁷⁰

Fellowship: competition (7/60), cooperation (6/60), and community (5/60). Although there were no significant differences between single-player or multiplayer mode in game play arousal⁸⁸ or enjoyment,⁸⁹ youth did prefer several social forms of play. Competitive^{59,72,90} and active videogame play⁷² was more appreciated when with friends. Adolescents, however, preferred to play the game with their parents when handling sensitive topics.⁶⁸ Youth liked being part of a social community when playing a game,^{67,71,90} not for sharing achievements,⁵⁶ but for sending and receiving messages among team mates.⁹¹

Having an opponent created higher positive affect.⁸⁸ They liked to play against a robot, but slow answering of the robot also led to frustration.⁹² A danger of overcompetition was mentioned, where schools competed against each other, which resulted in rivalry and frustration.⁹³ Youth were also interested in cooperative features.^{55,83,86} Boys less often had a preference for cooperative, competitive, or single-player games. They more often chose team competition⁹⁰ than girls.⁷⁷ Girls chose (individual) competitive play as their most preferred player mode.^{77,90}

Expression: customization (12/60) and creative freedom (6/60). Users wanted to be able to change the looks of characters and game objects,^{63,70,74,80,81,86} by skin tones,^{69,77,82} body,⁷⁷ hair,⁷⁷ eye color,⁷⁷ facial features,⁷⁷ colors,⁷⁷ clothes,^{77,82} fashion,⁷⁸ and accessories.⁷⁷ Limited options to avatar customization inhibited game engagement.⁹³ In terms of creative freedom, youth preferred to play with friends of the same competence level⁷² and to choose their own team members,⁹⁰ although some preferred to be randomly allocated to prevent imbalanced teams.⁹⁰ In active videogames, control in moving their body parts was very important.⁷⁵ Active videogames often provide a set number of sports to imitate, yet, adolescents preferred having free choice on how to move.⁵⁹

Discovery (2/60) and fantasy (1/60). Mixed findings were reported in how important youth considered discovery such as quests and exploration,^{73,77} Only one study assessed fantasy in relation to engagement. Children felt immersion would have been higher if the story had integrated fantasy role playing.⁵⁸

Dynamics

Rewards (18/60). Rewards were generally appreciated,^{55,67,72,91} but most appreciated when not too hard to achieve,^{74,84} handed out fairly,⁹⁴ clearly related to the game objective,⁶² and when there was still room for personal

improvement (e.g., less appreciated when users reached the top of the leaderboard).⁹⁵ Rewards led to frustration among players who did not win any rewards, but saw other players winning rewards.⁹⁰ Preferred rewards were stars, tokens, gems, or unlocking new game aspects.^{60,68–70,80} Points and leaderboards were not very important.⁷⁷ Older female youth preferred to collect items to customize abilities, weapons, or clothes. Older male youth preferred earning points for new lives, energy, and weapons.⁸⁰ Boys preferred recognition-based rewards (e.g., trophies), whereas girls preferred material rewards (e.g., vouchers).⁷⁷

Feedback on game performance (9/60). Users preferred to self-monitor their game play (e.g., game progression).^{55,74,85,86,90,95} Receiving feedback on game performance and self-monitoring during game play were generally appreciated.^{74,75} Feedback should be realistic (e.g., applause sound), match game performance (e.g., player failed to stop and as a result falls),⁷⁵ be accurate, and easy to interpret. A dashboard may need to be integrated within game activities and tied to game goals and achievements, as dashboard charts proved difficult to interpret.⁹⁶

Instructions on game play (9/60). Players appreciated information on how to perform the target behavior (e.g., physical activity) in the game.⁸² How these instructions are given may, however, also be a barrier for user engagement when instructions are unclear.^{58,60,62,95,97,98} For example, in one study, users misunderstood the provided suggestions for game activities as mandatory tasks, which limited their perceived choice in the game and reduced their appreciation.⁹¹ Adolescents suggested including more and clearer instructions.⁶⁰ It is yet uncertain how to best do so: offering a training mission did not result in higher engagement compared with those without training,⁹⁷ and providing instructions on game play in between missions even inhibited engagement.⁹⁹

Time (6/60). Even though time pressure was considered as challenging and fun,⁵⁸ users disliked having to start over with every small error they made,⁸⁵ and not having sufficient time to complete the challenge,⁷⁴ for example, when time provided to complete minigames was too short.⁶² Potential methods to balance time pressure and sense of achievement may lie in using accumulation systems, in which the remaining time of a session was added to available time for a next session,⁷⁵ or in the ability to pause and continue the game,⁸⁵ which could stimulate discussion between peers.⁷⁹ These methods were appreciated by youth.^{75,79,85}

Active or passive play mode (5/60). Studies showed mixed results. Quantitative studies showed no significant differences between active game play and passive game play on game anxiety¹⁰⁰ or enjoyment,¹⁰¹ but did show differences in preference, favoring active game play.^{102,103} A qualitative study showed that adolescents felt more engaged in active game play than in passive game play.⁷²

Game goals (3/60). This was considered the third most important feature in usability testing.⁷⁵ Studies indicated goal setting helps players to adjust the game difficulty,⁷⁵ which makes it individually challenging and achievable.⁹⁵

How goal setting is best provided may be age dependent: calculating points to set goals was too difficult for younger children and reduced their fun.⁹⁵

Mechanics

Game controllers (10/60). Youth preferred to control the game by voice interaction,⁸⁵ their own body movements,^{59,75} a joystick or handheld controller,⁵⁹ or a mouse rather than LED gloves or hand motion tracking gloves.¹⁰⁴ Users disliked having to press buttons.⁷³ Not knowing how to use controllers, malfunctions or slow response of game controllers increased distraction and reduced usability.^{59,62,72,75,98}

Device and media requirements (10/60). The following formats were preferred: (1) a tablet instead of a computer,⁸⁵ (2) integration with real-life environment,^{61,73} (3) integration of different media,^{65,83,92,105} and (4) regular updates with new (e.g., quiz) content.⁶⁷ Devices and media platforms that restricted players to the inside environment (e.g., balance board in an active videogame) were less preferred.^{57,75}

Genre (7/60). Genre was considered as highly important by users.⁷⁷ Action/adventure games were generally most preferred. Adolescents also had a preference for fantasy games⁷⁰ or racing games.⁷² Some gender and age differences were noted. Boys preferred racing, sports, fighting, survival, action, and collection.^{57,59,72,77,80} Girls had a preference for life simulation, dancing, singing, sports, puzzle/strategy, racing, and caring for animals.^{57,59,72,77} Elements such as harvesting, jobs, quiz, sports, helping, and caring were of least interest to adolescents.⁸⁰

Age differences included younger adolescents (9–12-year olds) preferred simple games, with no prior training (sports, racing, and adventure), whereas older adolescents (13–15-year olds) preferred shooting games and story-based games.¹⁰⁶ In comparison, younger male adolescents preferred aggressive action and younger female adolescents preferred dance games.⁵⁷ Older male adolescents preferred dance games whereas older female adolescents preferred a game that was related to calorie counting.⁵⁷

Behavior change techniques

Shaping knowledge information on educational content in serious games (11/60). There were mixed results on whether the game should be announced as educational¹⁰⁷ or just as a fun game.^{58,77} Various studies showed that adolescents wanted a balance between fun and educational content.^{60,64,68,74} Educational facts should be correct, realistic, trustworthy,^{67,105} nonchildish, nonjudgmental, not lecturing, and presented from the target group's perspective.⁶⁷ Users suggested to emphasize positive effects of the healthy behavior rather than negative effects of the risk behavior.⁶⁷ Whereas some adolescents wanted a variety of health topics,⁸³ others suggested to focus on one health topic of the player's choice.¹⁰⁸

Personal goal setting (2/60) and self-monitoring (1/60). Goals are defined in terms of the player's behavior and need to be met outside game play (e.g., glucose level or daily steps). It differs from the game challenge, which directly relates to game play (see game goals). To help the player

meet the recommended levels of health behavior (e.g., glucose level), users wanted to have goal-setting features in the game.^{90,107} Children showed a preference for a game to include continuous self-monitoring to their health-related behavior (e.g., glucose level).¹⁰⁷ Users were dissatisfied with the accuracy of the self-monitoring tracker. Data transfer problems between tracker information and game rewards led to further dissatisfaction.⁹⁴

Main findings

Results showed that various game features were associated with user engagement in digital (serious) games, such as an attractive storyline, adaptable to gender and age, including diverse (antagonist) characters the user may identify with, high-end realistic graphics, well-defined instructions, which can be skipped, in combination with clear feedback and a balance of educational and fun content (Fig. 2).

Discussion

This systematic review summarized studies that examined associations between game features, such as MDA, and BCTs, and youth's engagement with digital (serious) games for healthy lifestyle promotion. This review was the first to focus exclusively on digital (serious) games for healthy lifestyle promotion among youth.

Aesthetics were examined most in relation to youth game engagement. Especially adding a storyline and ensuring identification with and a diversity of characters were aesthetic aspects that related to higher youth user engagement. Although our review is not the first to point to the importance of these features,^{30,109,110} these features are still only infrequently applied in serious games^{11,30,111,112} and active videogames ("exergames").^{113,114} Our review moreover identified a diversity of characters and antagonists as engaging features, which is an addition to literature that has already reported on the relevance of character identification for game engagement.^{11,30,35,110} Including an attractive storyline that is adaptable to gender and age, with diverse (antagonist) characters that the user may identify with, may hold substantial potential for youth digital (serious) games to be more engaging.

The relevance of high-resolution and three-dimensional realistic graphics was also not yet identified in earlier systematic reviews among youth,^{110,115} and can provide new angles for the design of an engaging game for youth. Our review also reported on achievable challenges; social features such as community, competition, and cooperation; high-end graphics; and avatar customization options, as desirable features for youth engagement. Game aesthetics showed the most consistent positive associations with immersion, which may suggest that aesthetics are especially important for this dimension of engagement. Most studies on aesthetics (with the exception of graphics and customization) were of moderate to high quality, lending support to the robustness of these findings.

Dynamics and mechanics were examined less often than aesthetics in relation to youth game engagement. Studies focused on fair and achievable rewards, clear feedback, and device and media requirements (e.g., integrating different media and integration with their real-life environment), which were all associated with higher user engagement.

Several of these features, such as rewards and feedback, are also well integrated in current digital (serious) games for youth.¹¹⁶ Instructions to play the game were not associated with higher user engagement, as users often misunderstood or skipped these. Our findings suggest that giving well-defined instructions which can however be skipped, in combination with clear feedback, is important for user engagement and may present an additional opportunity for more engaging games for youth health promotion.

Dynamics and mechanics were most often studied in relation to perceived usability, affective engagement, and interest. This may suggest that features contributing to the overall functionality of the game (e.g., rules and rewards) are still most often measured in usability studies.¹¹⁷ Studies on dynamics (feedback and time limit) and mechanics (game controller) were of poor quality. Results, therefore, need to be interpreted with care. With the exception of studies on rewards, studies that examined dynamics and mechanics were of poor quality. Results, therefore, need to be interpreted with care.

BCTs were not often studied in relation to user engagement, but predominantly showed positive associations, and were reported in high-quality studies. Many (serious) digital games for youth also implement several BCTs, such as personal goal setting and self-monitoring.^{11,118} Providing a balance of fun and education content was identified as an aspect that was important for engagement.

To our knowledge, this review is the first that takes into account the health information presented in digital serious games as an element of engagement. Several studies affirm that educational content and engaging game play need to be well aligned,^{119,120} yet to the best of our knowledge, there are currently no guidelines on how to do so. Our review suggests providing educational facts on health behaviors of the player's choice, which are nonjudgmental or lecturing, emphasize positive effects of the healthy behavior from the target group's perspective, and are not childish for a younger group of youth.

This review started from the assumption that what is important for youth game engagement may differ from what is important for adults and may also differ by the intended purpose of the game (i.e., healthy lifestyle promotion). When comparing results with existing reviews on user engagement in other age groups and topics, some features associated with user engagement appeared shared across age groups and game purposes, but also divergences by age groups were found. Similarities in engagement-enhancing features between youth and adults existed in the importance of cooperation, competition, feedback, challenges, storyline, identification with characters, and sound and music.^{31–33,121} Divergences were found in fantasy, the pace of the game and features that evoke negative emotions as important for adults but not for youth.^{21,34} This underscores the need to examine engagement-enhancing features and design considerations specifically by age of the target group. Both in health- and nonhealth-related games, multimedia elements, storyline, identification with characters, challenges, and rewards were associated with higher user engagement.^{110,115}

These findings also highlight some needs for further investigation. First, of the large number of studies on digital (serious) games for health promotion among youth, relatively few had investigated an association with user

engagement. Moreover, some studies only measured a particular dimension of engagement, whereas engagement is a multidimensional construct.¹²² Widespread use of valid multidimensional measurements of engagement appears to be lacking in evaluation studies of serious games,¹¹⁷ and deserves more attention. Second, our review cannot pinpoint which feature is most important for engagement. This would require a meta-analysis of quantitative randomized-controlled trials (RCTs), whereas only three such studies were included.

Moreover, this review describes each feature separately, whereas features may interact and contribute differently to engagement in combination with each other than when used in isolation. The dose and combination of features deserve further research and may be considered to be studied in RCTs, or alternative research designs as experimental factorial design.¹²³ Furthermore, it is important to mention that not every person is equally engaged in the same game,¹²⁴ therefore, customization may be further applied to study effective engagement¹⁸ for individual players.¹²⁴ In addition, a differentiation between healthy versus disease condition may be considered to detect preferences for engaging game features.

Strengths and limitations

Some limitations need to be noted. Although no publication bias could be assessed due to the inclusion of various types of study designs in our review, the high rate of positive associations among the features that were studied (77%) may suggest that features that are unrelated or negatively associated with user engagement were not reported in studies or did not get published. This may provide a biased view, overestimating the positive association with user engagement. Moreover, the quality of many included studies was rather low as few experimental studies were found. Currently a diversity of research designs is used to measure correlates of user engagement, which is reflected in this review. Moreover, a variety of engagement measures and dimensions were reported in the individual studies, precluding a direct comparison of results between engagement measures.

Our keywords specifically used the term “game.” Older studies may have used other terms such as computer-assisted instruction or simulation. However, our review was restricted to relatively recent literature when the term games was already well established, reducing the risk that relevant studies may have been missed. Moreover, bibliographies of included studies were hand searched to reduce the risk of missing relevant studies.

In this review, the results were structured in terms of the MDA framework, which is usually used in game research and game development. However, we are aware that other concepts could have been used, for example, differentiating between elements of representation and simulation^{125,126} This review did not specify the device on which the game had to be played. This would be of interest to consider in future studies. The review also had several strengths. This review included several studies, investigating engagement in (serious) digital games. Both qualitative and quantitative studies were included, to give a comprehensive overview of the state of the art. The review was conducted in a methodological rigorous manner, using well-established instruments for coding of content and quality, and assessing inter-rater reliability.

Conclusions

Various game features such as MDA, but also BCTs, were associated with engagement in digital games for health lifestyle promotion among youth. Aesthetics were examined most often, and positive associations were especially found in relation to immersion. Adding an attractive storyline, adaptable to gender and age, including diverse (antagonist) characters the user may identify with, and high-end realistic graphics may hold substantial potential for increasing youth's engagement in digital (serious) games.

The role of dynamics and mechanics for youth engagement in games was examined less often, but when studied, it especially focused on usability measures. Giving well-defined instructions, which can be skipped, in combination with clear feedback may present an additional opportunity for more engaging games for youth health promotion. BCTs were not often studied in relation to user engagement, but predominantly showed positive associations, especially by providing a balance of educational and fun content.

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Supplementary Material

Supplementary Table S1
Supplementary Table S2
Supplementary Table S3
Supplementary Table S4

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