A Survey of Active Video Game Literature

From Theory to Technological Application

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Abstract—**Childhood obesity is a major phenomenon that has been dramatically spread in different countries. This prevalence draws the attention of researchers to find the reasons that help increase this problem. One of the main contributing factors for increasing the children and adolescent weight is the sedentary nature of their life. With the advent of technology these days, many children and adolescents are engaged in different seated activities and drawing them away from physical activities. Hence, finding a way to attract and motivate children and adolescents to exercise needs to look at the activities they most prefer. Playing video games is one of the favorite activities for children. However, this activity is defined as a seated activity that helps increase the sedentary behavior. Literature revealed that time spent in playing video games is linked to children's obesity and the decreasing levels of physical activity. From this finding, the idea of converting this passive activity to active one has been developed. The new form of games called active video games (AVG) promises innovation for active life style. The new generation of video games which require players' physical interaction provides the opportunity for children to play their favorite leisure activity and exercising in the same time.**

Before one can effectively conduct research into this realm to provide innovative and useful AVG's a very diverse number of disciplines and fields need to be surveyed. This paper represents a comprehensive literature review conducted over a number of areas that include video games, engagement, active video games, and available technologies for AVG development.

Keywords-Active Video Games; Childhood Obesity; Kinect Sensor; Exergaming.

I.   INTRODUCTION

Childhood obesity is a major phenomenon that has drawn researchers' attention throughout the ages. Different literature has investigated the increase in prevalence of this problem around different countries. In England, data collected in 1998 indicated that there had been a significant increase in the prevalence of obese and overweight children and adolescents. The prevalence grew from 13 to 20% between 1994 and 1998. The authors estimated a continuous increase [1]. In Australia, the [2] stated that 19-23% of Australian children and adolescents were either overweight or obese during the period 1995-1997. Furthermore, according to [3], there was a significant increase in the number of overweight children and adolescents aged between 2 and 19 in the United States from

1999 to 2004. This trend was assumed to be continuing. This increase was apparent in both male and female children and adolescents. The prevalence in females jumped from 13.8% in 1999-2000 to 16.0% in 2003-2004. In males the prevalence soared from 14.0% to 18.2% in this period [3]. A recent study conducted in the US indicated that the prevalence of obesity in children and adolescents was 16.9% in 2009-2010 [4]. This problem has a number of negative implications for health such as diabetes, heart disease, certain forms of cancer, and sleep-breathing disorders [5].

In an attempt to elucidate the potential reasons for the spread of obesity among children and adolescents, different literature investigated the reasons behind the increase in this problem. One of the major reasons for this problem was related to decreasing levels of physical activity as well as an increase in the level of sedentary activities amongst young people. There has been a large amount of research into the relationship between sedentary activity, physical activity and obesity in children and adolescents [6] [7] [8] [9]. In Canada, a study that covered a large sample of population indicated that physical activity is a tool that can be used to prevent the problem of overweight and obesity while sedentary activity such as playing video games could contribute to this problem. There is a strong relationship between children obesity and physical inactivity in Canada [6]. Another study [7] revealed that both physical and sedentary activity play a major role in obesity among children and adolescents. For this reason in order to combat childhood obesity both sedentary activity and physical activity should be targeted [7]. More specifically, there is a strong relationship between screen-based activity and increasing Body Mass Index (BMI) among children [9]. In this study it was demonstrated that children who are involved in screen-based activity and who do less vigorous physical activity are more likely to have a higher BMI [9]. Furthermore, there is a strong association between video game play and obesity in children [8] especially among younger children [10]. It has been postulated that this is related to a decrease in physical activity associated with increased time spent playing video games [10]. Therefore, effective strategies to help increase physical activity levels and decrease the sedentary behavior among children in order to prevent childhood obesity are necessary [6] [7] [9]. For the above reasons, one study concluded that children should be encouraged to reduce time

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spent in sedentary activity, especially watching TV and playing electronic games [8].

There are a number of barriers that prevent children and adolescents participating in outdoor physical activity. As a flow-on effect the levels of sedentary activity are increased. These barriers include safety as many families prefer their children not to play outside due to crime in their neighborhoods [11] [9]. Other possible reasons relate to the presence of parks in close proximity to adolescents' houses as adolescent girls who live near parks with active facilities are more likely to engage in physical activity [12]. Another potential contributing factor that has been suggested relates to environmental conditions. For example when there is bad weather, children are prevented from participating in outdoor activity [13].

Physical activity is recommended for children and adolescents because of its benefits on their overall health, development, skills, fitness and behavior. It is therefore recommended that physical education should be started at an early age and continued into adolescence. Strategies which motivate children to become more involved in physical activity and reduce the amount of sedentary behavior they undertake should be widespread in communities, schools and homes. It is recommended that children and adolescents participate in at least 60 minutes of moderate to vigorous physical activity daily [14].

Playing video games has been established as an activity that children enjoy. Video games are a preferred activity for children especially in situations where there are few other available options for example when the weather is bad or there are no other children around to play with. Video games can also act as a medium for avoidance of tasks children do not want to do for example homework. Lastly, video games provide children with an opportunity to compete and play with their peers. A study [15] conducted among 1111 children aged between 7 and 14 years investigated how often children play video games. Regarding the frequency of video game play, 55.7% of boys and 29% of girls played video games on a regular bases whereas 40% of boys and 51% of girls played them casually (less than once a week). It was reported that 6% of boys and 20% of girls do not play video games at all.

As has been mentioned above, children love playing video games [15]. It is also vital that they are involved in daily physical activity [14]. It is problematic that these activities can potentially become competing priorities for children. The proposed solution for this is the use of active video games. This form of game integrates the entertainment of playing games with the physical interaction of the user to control the game play. Moreover, a majority of children stated that their favorite leisure activities included different kinds of sports [15]. Therefore, developing active games that simulate real sports would offer a fun and engaging platform for these active games. Active video games provide a perfect opportunity to combat childhood overweight and obesity through their ability to combine physical activity and entertainment whilst reducing sedentary activity and consequently this is a very important area of research and there are many literature reviews which surround it [16] [17] [18] [19].

The remainder of this paper has Section 2 describing the methods of literature review research that include which databases have been visited, the search strings that have been used and the articles that have been reviewed. The starting point of the topic of this literature review is in Sections 3 through 11 provides information about video games, features of video games that lead to engagement, active video games, the potential implications of active video games on children's health and development such as the effects of these games on children exercise adherence, fitness and skills, design aspects of active video games, and finally technical issues of design and development of active video games. Section 12 discusses the main research questions derived from this literature review that have formed the basis of a new research project being conducted by our group. A conclusion is provided is Section 13 followed by the References used in the paper and research to date.

II. LITERATURE AND REVIEW METHODS

A literature search was conducted which focused on three main areas: active video games for adolescents, engagement in video games and video games and health. A variety of databases were visited including ACM Digital library, IEEE Explore, ScienceDirect and some journal databases such as Pediatrics. Different search strings were used, for example "Active video games", "Active video games and obesity in children", "Obesity in children and adolescents", "Obesity and video game play", "Video games and engagement", "Engaging to active video games", "Active video games and health", "Exergames", "Motivation to play active video games" and "Designing active video games". There are 71 articles included in this literature review including 41 journal articles, 24 conference papers and information from 5 books and 1 website. A majority of the journal articles have a high citation rate.

III. VIDEO GAMES

Video games are an interactive multimedia that links the real-time user with a virtual world behind a display using images, animations and sounds. It is where the user's interaction takes place within the video game story forming the player's experience [20].

The video game is a dynamic medium capable of everything from educational to leisure. It is multifaceted in its abilities to tell a story and stimulate the audience. A video game is an art form. Lot to be negated is the video game's capacity to provide a means of social interaction [21].

Video games have the ability to create a positive, fun, entertaining atmosphere amongst players [20]. The main feature of the video game that differentiates them from other media is their need for player interaction. In order to explore and advance in the game world, the player has to have a certain amount of skill [20].

A. Areas Where Video Games have been used

Different literature investigated the potential for the use of video games in a number of different contexts due to their appealing and engaging characteristics. Researchers in this area were interested in studying the use of video games as a learning

tool. As video games have become more widely used by different ages, it has become easier to implement them as an educational tool, which can positively affect the player's knowledge and skills if effectively applied [22]. Educational games can be developed using a state-of-the-art commercial game development approach with the enhancement of developed educational models [22]. The authors in [22] applied this approach by developing an educational game called SeaGame which reached a statistical similarity with successful commercial video games along a number of specific dimensions and at the same time enhanced the knowledge and skill acquisition process. Furthermore, by comparing the computer-assisted instruction method with the computer-based video games method in knowledge acquisition, the results demonstrated the effectiveness of the video games as a way of facilitating the cognitive learning process [23].

Video games are considered an effective tool within the education context because of their positive impact on players' cognition and knowledge [23] [24]. These positive impacts include:

- Improving cognitive and reading skills.

- Motivating logical thinking process.

- Strengthening observational skills.

- Acquiring basic and factual knowledge.

- Enhancing the abilities of problem-solving and decision-making.

- Developing strategic planning.

- Supporting spatial awareness.

In order to achieve all these benefits, educational video games need to be more appealing. A specific study was conducted in Thailand [25], which was interested in educational games that are designed particularly for the purpose of learning English. This study identified the recommended characteristics for these types of games. In this study a group of undergraduate students were surveyed in order to obtain their opinions on making these games more engaging. The study is based on identifying the common features of the ten most popular games and comparing those features with the common features of the most popular language learning games. The study concluded with the four suggested characteristics that should be included in language games to make them more attractive to learners [25], including:

- Enhance the animation design.

- Involving a variety of play modes, challenges, competitions and sound effects.

- Providing a help tool as well as re-play feature.

- Including a reward feature and a group player feature.

Furthermore, an additional study suggested that video games could be an effective learning tool for rural children who cannot attend schools because of their low socioeconomic status that forces them to work and support their families

taking into account the inexpensive platforms of these games [26].

One of the important areas that utilize video games to deliver knowledge is the health education area. Using video games in this area has been classified into three categories based on the research that has been done in this context [17]. These categories include:

- Video games that serve to increase awareness of prevention strategies and management of different diseases.

- Video games that are designed for the purpose of nutritional education.

- Video games that help increase awareness of first-aid practices.

For all of these categories, it has been demonstrated that video games have the potential to reach both children and adolescents positively influencing their attitude towards health education, health knowledge acquisition and potential behavioral changes [17]. With specific regard to disease awareness, prevention and management, these health educational games target a number of aspects of children's behavior including self-concept, self-efficacy, health knowledge and skills and communication and social support. This is expected to lead to better health and lower health care costs [27]. For example, some games were designed to manage chronic health conditions such as asthma and diabetes and others were designed to prevent adverse health behavior such as smoking [27]. Evaluation of these games demonstrated their effectiveness in encouraging better health behavior in children as well as they were fun and engaging [27]. Therefore, it is recommended that these kinds of games should be added to health programs as they improve the patients' behavior and encourage continuing self-care and self- monitoring as well as supporting communication and social aspects of child development. Moreover, because of their enjoyment factor, patients' would be likely to play such games in their free time leading to a good utilization of free time for health education purposes [27].

B.   Video games and Adolescents' Health

Playing video games is a very popular activity among children and adolescents [15]. While some video games have positive affects especially the ones that were designed for health promotion purpose [17] [27], they can also negatively affect adolescents' health. Some studies demonstrated that adolescent obesity is strongly related to time spent playing video games [8, 10]. Spending large amounts of time playing video games leads to an increase in the Body Mass Index (BMI) among children and adolescents. A study that was based on the 24-hour time-use diaries of 2831 participants aged between 1 and 12 years old, revealed a strong relationship between obesity in American children and video games use, especially among younger ages (under the age of 8) [10].

Therefore, video games play a significant role in the prevalence of childhood obesity, particularly in America [10]. Moreover, a study of 3365 Portuguese children aged between 7 and 9 years also revealed a significant association between

times spent playing electronic games and childhood obesity [8]. The source [5] stated that obesity has negative implications for health, such as diabetes, heart disease, cancer and sleep-breathing disorders. Taking this into consideration, strategies that encourage children to reduce time spent in sedentary activity, especially playing sedentary electronic games should be implemented [8].

With the new generation of video games that involve physical interaction, "Active Video Games", playing video games can trend towards utilization of video games as a medium for exercise and physical activity. This has the potential to positively impact children's health. Active video games have the ability to reduce sedentary life-style in children and hence avoid the health problems that are associated with obesity [28] [29] [30]. In forward sections 5 of this paper, active video games will be discussed thoroughly, especially their impact on children's health and development.

IV. VIDEO GAMES AND ENGAGEMENT

A. Engagement Concept

Engagement within a gaming context refers to the positive feeling an individual experiences when they are involved in game play [31]. Enjoyment of the game is the primary goal of game developers in motivating individuals to play video games [32]. The author of [32] presented the GameFlow model which describes the different elements of enjoyment within games. These elements include:

- Concentration element: when players attention is most focused on game play.

- Challenge element: the inclusion of a variety of levels which range in difficulty appropriate to the target audience.

- Player skills element: as players progress through the game it should be possible for them to increase their skill level.

- Control element: the ability of players to have accurate control over game objects to carry out game play.

- Clear Goals element: the provision of clear game goals appropriate to game stages.

- Feedback element: the provision of appropriate feedback as player's progress through the game.

- Immersion element: players should feel themselves being naturally absorbed into game play.

- Social interaction element: there should be opportunity for social interaction in game play to increase enjoyment.

B. Design Considerations of Engaging Video Games

As the main purpose of video games is the integration of engagement and entertainment, there are a number of factors that need to be considered in game design. These factors, include player positioning, game narrative and interactive design, and mainly depend on the genre of the game [33]. The first factor of engagement, 'player positioning', has been developed throughout the years and moved through different stages. Starting with two-dimensional games where the player views the game from the out-side perspective. Moving to the side scrolling view where the player can explore the hidden areas of the game and move through different dimensions. Then advanced to the isometric view, which is also described as the 'two and one half dimension' view where the player can view the whole game area and discover further areas as the game progresses.

The player positioning trend then moved to the first-person perspective where the players feel as though they are inside the game world and moving around in the virtual world. The development of player positioning from outside view to inside view helped increase player engagement to video games. Regarding the second element of game design 'game narrative', the authors in [34] stated that unlike other narrative-based media, narrative in games has a different meaning and role within the game context. From the play-centric perspective, its role is related to creating entertaining and engaging play which can enhance the game play experience [34]. If 'game narrative' is integrated well, it will further support player engagement and overall game experience [33]. Regarding 'interactive design', game developers should be aware of game play settings, the roles and characters, actions and feedback [33].

Furthermore, video games should be challenging and competitive with a balance of difficulty levels in order to continue to be fun and engaging [26] [35]. Video games are more enjoyable when they offer many different possibilities to act (challenging element) as well as a strong necessity to act (competitive element) [35]. The levels of the challenge difficulties in the game play certainly affect the engagement of the player which can be decreased if these levels do not change [36]. However, increasing the number of obstacles or enemies in a game play would be inefficient for the purpose of increasing difficulty. More appropriate strategies would be as adding additional sub goals to the game play [26].

Some researchers referred to the environment, life style and educational level of the players as important factors that should be considered when designing a video game [26]. Some children who live in rural countries cannot understand the game play of some western video games because of their low level of education resulting from their poor life conditions [26]. From this point of view, the authors in [26] found that it is important to design a special kind of video games for these children and more importantly these games should be based on traditional games that they used to play in their everyday life. Utilizing the strategies of these 'real life' games to design a video game for these children could make such a design more successful and the game more fun and engaging [26].

C. Proposed Strategies to Design Engaging Video Games

From the literature that was considered in this area, a number of strategies have been concluded which could be used in design engaging video games. These strategies include:

- Finding games that the children do like to play in their day to day life, analyzing the factors of enjoyment in these games and then integrating these factors in the video game design [26].

- Finding the popular commercial video games that have a high rate of players and analyzing the engaging factors of these games in order to utilize these factors in the design of new video games [25] [37].

- The 'playtesting' method in developing video games is based on continuous developing and testing in order to fix the problems of the previous prototypes. The end result is an engaging design which is attractive to the targeted audience [38].

V.   ACTIVE VIDEO GAMES

Active video games (AVG) refer to video game technology that is based on player motion as the main interaction between the players and game play. These games depend on players' body movements and gestures in the real world to control the objects in the virtual world. Examples of gaming systems and platforms that support this kind of active play include Microsoft's Kinect XBOX 360, Nintendo's Wii and PlayStation Move [39]. As active video games require player's physical interaction, a variety of input hardware have been developed to support the play mode of these games. There are a number of input devices which have been used with active gaming systems to detect player's motion and interaction including; accelerometers and gyroscopes, vision based devices, ergometers (exercise equipment's), pressure and touch sensors (pads and mats), and special purpose devices [40] [41]. An earlier study has classified the input devices of active video games into four main groups according to their usage. These groups are exercise bikes, foot pads, motion sensors and other physically interactive games devices [42].

The recent classification model of input devices of active video gaming [40] involves six types of input techniques:

- Gesture: This technique is represented when players move their whole body, or parts of it, in a structured form to perform an action in the game such as the movement of the hand in forward and backward directions when playing a tennis game. Once the gesture is completed, the programming command of such a gesture is invoked.

- Stance: This type represents the player position in a certain instant of time such as in dancing games where the player has to be in a specific position at a given time according to the music.

- Point: this technique is demonstrated when a player points to a specific area on the screen using either a finger, hand or controller devices.

- Power: This type is related to the degree of the player's physical exertion which is usually linked to the game character movement speed.

- Continuous Control: This technique is used for capturing and mapping the player's movement in the physical world with in-game objects or characters in the virtual world. For example, games where the players control the car movement using an invisible steering wheel.

- Tap: The input of this type is captured once the player touches a physical item or area during the playing time such as in Dance Dance Revolution where the player has to touch a specific location in time with the music.

This classification assists in forming an understanding of the input techniques involved in active video games [40]. Moreover, with the General Active Input Model or GAIM toolkit developed by [41], active video game programming can move towards simplification of the development process. This model is a class library that is based on the idea of abstracting the input from the hardware according to the active input classification provided in [40]. It supports interfaces for four types of active gaming inputs including IPower, IGesture, IPoint and IStance. It consists of three layers including:

- Abstract input layer which deals with the classes of the input types.

- Abstract device layer which deals with the classes of the input devices.

- Device layer which deals with the actual devices.

There are different possible devices for each type of input, such as the IPower type which supports two input implementations, one based on stationary bicycles (BikePower) and one based on heart rate (TargetHRPower). When a game is running, the appropriate implementation will be selected depending on the preferred and available hardware [41].

According to the GAIM model active game programming has a number of positive implications. From the programming perspective, it allows the games' developers to deal with a game input independently of the hardware used. Therefore, instead of writing a specific code for the input device, the focus would be on the type of the input the game supports. From the technical perspective, a game can be played with a variety of input devices as long as those devices support the input type of the game. Therefore, the game needs to be able to be adapted to the input hardware that the player has, without special code for such hardware. A further advantage of this programming model is the opportunity it offers for multiplayer play mode with a variety of different input devices as long as those devices support the input type of the game [41].

While a large amount of active video game literature focused on the physical interaction benefits that encourage children to exercise and be more active [28] [43] [44] [45] [46], some literature considered using these active games as learning tools which can be utilized to develop children physically and mentally [47] [48]. In this area, the authors in [47] developed an active video game which supports both children's physical and mental exercise. This gaming system, called Learn-Pads, aims to improve mathematical skill in children using an exercising manner and entertaining atmosphere. This system consists of a mathematical active video game and four pads attached to a rug. It generates a mathematical expression based

on addition and multiplication operations and the players of the game have to answer the questions by stepping on the pads a number of times equal to the answer of the expression in order to advance in the game.

Evaluating the use of this game among children aged between 7 and 12 years demonstrated the efficacy of this 'Edutaining' system in developing cognitive, social and physical aspects in children whilst engaging and entertaining them. Involving such a system in school programs would be a good opportunity for children to enhance their learning and social skills [47]. This idea has been proposed by [48] who designed a physical interactive learning environment for English learning based on Input-Process-Outcome Game Model in a school environment. Lessons from the year three English course were the main content of this game-based learning environment. Evaluating such a system among third grade children showed the effectiveness of this tool in the English learning progress as well as its positive impact on learning motivation and attitude [48].

Active video games can be used as a medium for artistic expression. A recent study [49] created a project called WiiArts that combines active gaming with art in trying to explore the potential for active video games in the field of art. Unlike the traditional structure of active video games, which may include competition, exploration, action, puzzle, dancing and sport, the idea of integration of art aims to foster a creative entertaining atmosphere. This project used a pre-existing sensing technology provided by Nintendo WiiRemotes and a Sensor Bar, as well as a number of WiiArt prototype applications. The outcome of the project demonstrated that the game consoles of the active video games can be used in an artistic context to develop an interactive, imaginative and expressive art experience in a collaborative manner [49].

As active video games require the players' physical interaction [28] [37] [43] [44] [45] [46], researchers have investigated their potential in many different areas where physical interaction is valuable. One of these areas was physical rehabilitation. Active video games can be used as a rehabilitation tool to improve neuroplasticity and consecutive recovery of motor function [50]. Particularly people who suffer from spinal cord injuries and traumatic brain injuries could utilise such a tool to perform physical exercises in order to recover some of their body's original functions. The authors in [50] developed a game-based application that acts as a rehabilitation tool for balance training of individuals with a neurological injury. Evaluation of this tool among a number of patients and clinicians demonstrated the promise of active gaming in this area. There are a number of benefits of using active gaming in the field of medical rehabilitation:

- Reducing medical costs.

- No waiting periods.

- Reducing the need for rehabilitation specialists.

- Offering a home-based tool.

- The ability to be involved in an intensive rehabilitation program.

However, as rehabilitation measurements need to be accurate, game developers in this field need to be aware of the requirement for accurate and suitable motion tracking technologies to measure the patient's actual performance [50]. For example, using a Microsoft Kinect Sensor would be more appropriate in the context of rehabilitation games than motion tracking controllers such as Nintendo Wii Remote. This is because the Microsoft Kinect Sensor provides more accurate motion detection through the mapping of user movements in the real world with the character movement in the virtual world [50].

VI. THE IMPLICATIONS OF ACTIVE VIDEO GAMES ON CHILDREN'S HEALTH AND DEVELOPMENT

Active video games have a multitude of effects on children and adolescents. These effects are many and varied and include physiological effects (heart rate and energy expenditure), fitness and psychological and behavioral outcomes [19] [44]. The physiological impacts of active video games affect the player's internal organs in the short term for example the increase in heart rate some players experience during video game play is only temporary. Increasing player fitness, however, is a potentially long reaching impact of active video game play. The psychological and behavioral outcomes relate to the impact of active video games on the players' mental status, attitude, adherence and attendance [19] [44].

Active video games are an effective way to motivates people to exercise as well as encourage their adherence to exercise [44] [46]. Much literature has adopted this idea and renamed active video games which address player exercise as Exergames [28] [43] [45] [51] [52] [53] [54] or exertainment gaming systems [29]. Specifically, Exergames aim to motivate people to exercise by providing a safe, entertaining and engaging fitness atmosphere. Exergames have the potential to motivate children to exercise and change their sedentary life style to a more active lifestyle therefore, helping to eliminate the problem of obesity that is becoming increasingly widespread in children [54].

Some literature focused on the effectiveness of Exergames for children who are visually impaired [51] [52] [53]. Children who suffer from visual impairment are more likely to be overweight and obese due to decreased involvement in physical activity. The reasons for the relatively inactive lifestyle of visually impaired children include [51] [52] [53]:

- In order to exercise, visually impaired children need a strongly sighted person to guide them.

- Children with visual impairments are more likely to suffer an exercise related injury than their able sighted counterparts.

- They are often subject to feelings of embarrassment, ridicule and lack of knowledge regarding how to solve problems when they are encountered.

- The options for methods or physical activity are limited in the visually impaired.

Because of the effectiveness of Exergames in increasing children's physical activity [28] [30] [43], researchers have

deduced that Exergames would be a safe and motivating method of increasing physical activity in children who suffer from visual impairment [51] [52] [53]. The use of active video games by children who are visually impaired will help break down some of the barriers to physical activity mentioned above and help increase a sense of equity between children with and children without visual impairment. However, existing Exergames are highly dependent on the visual sense of players [51] [52] [53]. Studies have been conducted in this area and Exergames have been developed that are designed especially for visually impaired children. These new Exergames rely heavily on tactile and auditory sensation [51] [52] [53]. Evaluation these games among visually impaired players demonstrated that they involved comparable levels of physical activity to light intensity activity such as walking [51] or even moderate or vigorous activity [53].

One study [51] developed an Exergame called VI-Bowling that is based on the idea of Wii Bowling with some sensory substitution. A significant number of individuals with visual impairments belong to older age groups. Bowling is a game that appeals to older individuals. Therefore, the authors of this study targeted an older population with visual impairment for this Bowling game. In VI-Bowling, a dowsing technique has been implemented which is used to help the players find the right direction to throw the bowling ball. This game uses vibrotactile and audio cues. While the traditional version of Wii Bowling depends on the audio, visual and tactile feedback, the visually impaired version depends on only tactile and audio feedback. Some of this feedback is primary and requires the players' interaction and other feedback is secondary which simply informs players about a specific action within the game such as the sound of the ball rolling. Evaluation this game among visually impaired players demonstrated that it was both enjoyable and entertaining [51].

The researchers in [53] also developed a tennis game for the visually impaired called VI-Tennis. This game is based on the concept of Wii Tennis with some important changes suit visually impaired individuals. Two versions have been developed. One version relies on tactile and audio cues while the other depends on audio cues only. Both versions were evaluated using 13 visually impaired children. The results of this evaluation demonstrated no significant difference between the two versions in their effect on energy expenditure. A separate finding of this investigation was that the tactile/audio version achieved higher levels of enjoyment and satisfaction compared to the audio only version [53].

The authors in [52] developed an Exergame called Pet-N-Punch that is also based on audio and tactile cues. This game differs to the tactile/audio games developed before it in that it gives the player an opportunity to play using either two arms or a single arm. The result of testing such a game among 12 children with visual impairments demonstrated that players are able to achieve light to moderate levels of physical activity. This indicates that the activity level of this game was higher than the VI-Bowling game and less than VI-Tennis game.

In this area, researchers have suggested for future work to be done in designing engaging Exergames for blind people that motivate them to involve their whole body in active play. This

would have the effect of increasing overall physical activity levels and be accompanied by many health benefits. Moreover, it is recommended that there is a social component included in these games to further positively impact players' heath and behavior [52] [53].

Active video games can be used as a fitness tool to help improve the fitness levels [55]. The author in [55] demonstrated this idea using his own body as the main subject of his experiment. He played three active video games which differed in the interactions they involved. The three active games that were used were Dance Dance Revolution which requires the full body interaction, the EyeToy games which mainly require upper body interaction and GameBike games which utilize lower body interaction. After three months of daily 30 minute sessions plays, two benefits were observed by the author; weight loss and blood sugar level reduction.

The purpose of active video games is not merely entertainment. Active video games have been utilized in many fields. As well as exercise [44] [45] [46] which has been mentioned above, active video games have been used in fields such as art [49], education [47] [48], rehabilitation [50]. The use of active video games in these fields has led to the development of skills such as educational skills and social skills [47]. One important skill that active video games can build on is children's motor skills [56]. Motor skills can be classified into two groups, gross motor skills and fine motor skills [56]. Gross motor skills relate to the movement of the large body muscles and are developed as children physically grow through activities such as walking, dancing and swimming. Fine motor skills relate to the movement of the small body muscles which combine finger interaction with eye coordination and are developed with practice of activities such as crafts (cutting, sticking, and coloring) and other activities such as zipping and buttoning. Another investigation of this study [56] was to explore the different physical input devices of active gaming. The study determined that the Dance Dance Revolution mat and the accelerometers in Wii remotes as suitable devices for measuring and developing gross motor skills whereas the infrared camera in Wii remotes and the multi-touch screen are suitable devices for measuring and developing fine motor skills.

Physical skills are another essential skill which can be acquired using active video games [57]. One physical activity that requires particular physical skill is throwing which is a basic activity in many different sports. Continued practice from an early age is required in order to master this skill. Engaging children in this activity is difficult in its traditional form. Active video games can potentially provide a platform for development of the skills involved in throwing [57]. If this game is well designed, children will not perceive the game as a chore or daunting task or as a tool that helps them acquire a specific skill; instead they will be distracted by the engaging quality of the game and learn without realizing its implicit purpose.

Playing active video games has a significant effect on body composition. In particular, active video games influence energy expenditure and heart rate. A large amount of literature focused on the amount of energy expenditure that is associated with

active video game play. This was compared with the amount of energy expenditure associated with sedentary activities such as watching television and playing inactive video games as well as other active behaviors [28] [29] [30] [58] [59] [60] [61] [62] [63]. The amount of energy expenditure associated with playing active video games was significantly higher than the amount associated with sedentary activities [28] [29] [30] [58] [59] [61] [63].

Moreover, the rate of movement is increased when children and adolescents play active video games compared with inactive behaviors [28] [30] [60]. The literature also revealed that children expend more energy and move significantly more during active video game play than adults [60]. Other literature has a more specific view. They report that greater energy expenditure and activity counts are associated with playing the games that require whole body movements compared to those requiring only upper body movement [28] [29] [63]. One of the reasons for this variation is that active gaming that requires the full body motion is more effective in forcing players to physically move. For example, when full body movement is required players are less able to cheat during game play as they physically have to act out the maneuver required in the virtual world [45]. Moreover, it has been reported [55] that there can be variation in the physiological response, specifically heart rate, between different active games that use the same input software. One author [55] found that his heart rate varied when he was playing two different games even though both of them use the GameBike system for movement interaction. One potential reason for this variation could be more related to the level of player engagement. The author mentioned above found the speed and effort in his pedaling was related to his engagement in the game play.

While some literature demonstrated that active video games are effective in increasing the level of physical activity in children [28] [30] [43], others revealed that active video games have no effect on improving rates of physical activity [13]. There is still no evidence that active video games involve sufficient amount of physical activity that they can replace real sports and free play. In fact some literature insists that free play and real sport are more effective in increasing energy expenditure and movement rate [30] [60] [61] [63]. While some literature argued the inability of active video game play to meet the recommended daily amount of exercise [13] [61], others believed that these active games do meet the recommended intensity of daily exercise that is required for healthy life [29] [30], especially for young adults [62]. Nevertheless, active video games are an effective way to encourage children and adolescents to be physically active [28] [29] [30]. However, active video game play needs to be assessed over a long period of time in order to gauge how sustainable it is as a means of physical activity [28] [29] [30].

The significant increase in energy expenditure and heart rate supports the substitution of sedentary video games with the active form of video games as a potential tool to fight the obesity epidemic among children and adolescents [28] [29] [58] [59] [61]. Having a fun screen-based activity that offers an active experience is preferable to a screen-based activities that is fun but does not motivate physical activity among children [13] [28] [29] [58] [59] [61]. Moreover, these games have the

potential to reduce sedentary life style in children in circumstances where they are forced to be sedentary due to conditions not conducive to outdoor physical activity such as poor weather [13]. For this reason, further investigation into making active gaming more appealing and engaging for children should be attempted [13].

VII. LITERATURE EXPERIMENTS

This section describes some previous experiments that have been conducted to measure the physiological outcomes that are associated with playing active video games.

One study [58] tested the amount of energy expenditure, heart rate increase, step rate and perceived exertion that was associated with playing two active gaming systems (Dance Dance Revolution and two Wii Sports (Bowling and Boxing)) among 23 children aged between 10 and 13 years and compared the results with rest and treadmill walking activity. This study revealed that active game play and treadmill walking have a significant impact on increasing energy expenditure, heart rate and perceived exertion compared to watching TV activity while resting. Although the movement-base of the activity is different in the Wii sports games compared to Dance Dance Revolution (DDR) and treadmill walking (Wii sports games utilise upper body movement whereas DDR and treadmill walking utilises full body movement), the amount of energy expenditure is significantly increased in both of them. This amount of energy expenditure can be compared to moderate-intensity walking. Integrating active video games with exercise programs in overweight and obese children is a potential topic for further research. This includes research into the effects of active video games on body composition and cardio metabolic control [58].

A pilot study [43] measured how often individuals played active video games over a 12 week period and tracked individuals improvement in activity levels over the same period. This study conducted in New Zealand grouped study sample into two groups; the intervention group was provided with an active gaming system while the control group was not. Regarding the frequency of playing active video games, it was observed that time spent playing video games in total was less among the children of the intervention group compared to control group members. However, the time spent playing active video games was higher in intervention group. Time spent in playing inactive video games was higher among the control group. Regarding the promotion of physical activity, the intervention group was observed as having higher counts of physical activity compared to the control group. Waist circumference was also noted to have decreased over the 12 week period in the intervention group. For future work, it is recommended that the potential of these active games to affect body weight and BMI over prolonged periods of time is studied [43].

The study [59] looked at the amount of energy expended during different activities including resting, watching TV while seating, playing a traditional video game with hand-held controller, watching TV while walking on treadmill at 1.5 miles/hour and playing two active video games. This study used 25 children aged between 8 and 12 years. The results

showed that the screen based activities that motivate physical activity recorded a significant increase in energy expenditure compared to those that required seated behavior.

The work in [60] investigated the effectiveness of active gaming on energy expenditure and movement rates among children and adults. The study sample contained children and adults with a variety of different weights and BMI's. The energy expenditure amount and movement rate were measured in different circumstances including resting, watching TV while sitting and standing, playing inactive video game using hand-held controller and playing active video game (Wii Boxing). The results demonstrated the effectiveness of active video games in increasing the energy expenditure in children and adults as well as increasing movement rates. This increase was significantly higher in children than adults. The burning of calories incurred during active game play can be compared to some physical activities such as walking.

The researchers in [61] used a sample of 11 adolescents aged between 13 and 15 years to compare the amount of energy expended during inactive video game play using hand-held controller with the amount of energy expended playing active video games (Bowling, Tennis, Boxing). The results demonstrated that the amount of energy expended is significantly greater while in participants engaging in active play compared to participants engaging in inactive games. However, the amount of physical activity associated with active game play in this study did not meet the recommended amount of daily exercise for adolescents. Regardless of this, these games are an effective way to replace the sedentary activities. The study in [62] measured the amount of energy expenditure and heart rate among 13 young adults who were given the opportunity to play three different active video games for 30 minutes and were allowed to choose any game to play and as much as they want in order to simulate the real life situation. The results demonstrated the effectiveness of active gaming on the high rate of energy expenditure and the increase of heart rate. It can be concluded from this study that active video games are a good motivator for exercise and provide one method of keeping healthy.

The authors in [28] focused on the effect of active video games using the EyeToy active gaming system which employs a camera as an input device to place a player picture in the virtual world. In this gaming system, game play is controlled by the player's movement in front of the camera. Using 21 children aged between 10 and 14 years this study measured the energy expenditure, heart rate and activity levels during both active game play and inactive game play. The amounts of energy expenditure, heart rate increase and level of activity was significantly higher while participants were playing active video games. The amount of energy expenditure during active playing was comparable to that associated with light to moderate intensity physical activities such as skipping and jogging.

The research in [29] used a sample of 18 children aged between 6 and 12 years in Hong Kong to assess the energy expenditure and heart rate associated with playing XaviX active gaming compared with playing inactive video game using a mouse device. While there was a significant increase in

energy expenditure and heart rate associated with active gaming compared to inactive gaming, one particular game (XaviX J-Mat Jackie's Action Run) demonstrated an abnormally large increase in energy expenditure and heart rate. This game allows the players to step, squat, jump and stamp the enemies in the virtual world in order to advance in the game. The fact that the energy expenditure was so high for this particular game (XaviX J-Mat Jackie's Action Run) provides strong support for the use of active video games to meet the recommendations for physical activity in children and adolescents.

The study of [30] focused on the effect of body movement on energy expenditure among 13 adolescents aged between 11 and 17 while they were playing three active games (Wii Sports Boxing, Bowling, Tennis) and one inactive game. While there was a significant increase in body movement and its associated increase of energy expenditure and heart rate during the active play compared to non-active play, the upper limb movement was greater than the total body movement in all active games. On the other hand, the Wii Boxing game recorded a significant increase in energy expenditure and heart rate comparing to other active games. This is potentially due to the fact that Wii Boxing requires the both arms to be involved in the game play.

The researchers in [13] investigated the effect of active video games on children's weight, body composition, fitness and activity levels over a 24 week period using a comparison method. This study was longer, used a larger sample size and used a home-based setting compared to other studies in this area. 322 children aged between 10 and 14 years participated in this study and were assigned to two groups. The intervention group included 160 children who received an active gaming system with 5 active games. Children in this group were encouraged to play these games in an intensity that met the daily recommendations for physical activity. The control group included 162 children whose daily playing style was not changed. The results showed a small effect on the BMI and fat percentage in the intervention group compared to the control group whereas the physical activity and the fitness level did not differ between the groups.

The work of [63] conducted a test among children of male gender to measure the energy expenditure associated with active gaming play compared to both sedentary and physical activities. The study investigated the effect of the children's level of experience in playing active games and their fitness levels on the amount of energy expenditure. While the amount of energy expenditure that was associated with active game play was high, it can only be compared to the energy expended during self-paced walking, that is to say it was less than the amount of energy expended during self-paced running. Active video games are not the most effective tool for increasing cardiovascular fitness. It is interesting to note that the authors in [63] stated there is no relationship between the players' gaming experience or fitness levels and the amount of energy expended by individuals playing active games.

The study of [64] investigated the potential for the Dance Dance Revolution game to increase levels of moderate to vigorous physical activity and decrease time spent in sedentary activities among 60 children aged between 7 and 8 years in

home-based environment. The results showed that DDR significantly decreased the time spent in sedentary activity whereas vigorous physical activity levels slightly increased. The participants revealed that they were satisfied by and enjoyed playing DDR. Furthermore, parents like the idea of their children playing this game. Having additional support and encouragement to play this type of game, for example in schools or after school programs, may help enhance the engagement factor and then make the health benefits of playing these active games more widespread.

VIII.   ENGAGEMENT AND IMMERSION CONCEPTS WITHIN ACTIVE VIDEO GAMES CONTEXT

'Engagement concept' has been defined within the gaming and physical interaction area as the players' concentration, investment, enthusiasm, and effort to achieve either the winning goal or their personal goals [57]. The term 'Immersion' refers to a mental state where the person's full attention is given to a specific environment. Within the game context, immersion refers to players' full attention and awareness being concentrated on the game play [65] [66]. Therefore, the idea of immersive games relates to aiming to make the player completely involved in the virtual world [65]. The literature defines three main characteristics of immersive games. These characteristics include loss of self-awareness, loss of social-awareness and loss of game-awareness. The game designers implement strategies relating to each of these characteristics to achieve the effect of immersion. For example, in order to achieve a loss of social-awareness in a player, the game world should be designed in a way that encourages player's to forget about the real world surrounding them [65].

Furthermore, a new concept has emerged called neo-immersive games. These games' characteristics are the inverse of the immersive games characteristics including awareness of self, awareness of others and awareness of game. The new generation of video games that involve physical interaction are examples of neo-immersive games. This change from immersive to neo-immersive games has been successful as it enables game technology to be adapted to players' requirements. Another reason for the success of this change from immersive to neo-immersive games is a movement from loss of attention and awareness of gamer's physical surroundings to heightened awareness and attention of gamers physical surroundings [65].

On the other hand, authors of [67] believed that active gaming that requires body movement has a strong effect on the player immersion because of the use of the body interaction as an input tool. This type of physical interaction provides further motivation for players to be immersed in the virtual world [67]. Generally, there are four features that affect the state of a player's immersion in active video game play. These features are [67]:

- The natural mode of control which is represented by movement of the whole body or of specific body parts to play the game. This gives the game play a more natural manner as the player can interact with the game in the same way they would interact in real life activities.

- Mimicry of movements where the interaction of the players in the real world is mapped to the avatar movement in the virtual world.

- Proprioceptive feedback which facilitates sensory immersion.

- Physical challenges which are associated with active gaming systems.

IX.   DESIGN CONSIDERATIONS OF ACTIVE VIDEO GAMES FOR THE PURPOSE OF EXERCISE

As mentioned earlier, active video games have been used within different contexts such as art, education and exercise. The active video games that have especially designed for exercise and physical activity promotion are referred to as Exergames. Development of these games has several main aims which include sustainability, engagement, fitness and activity level, maintaining engagement, enthusiasm, and motivation facotrs.

A.   Sustainability

In order to achieve the physical and health benefits of Exergames, they should be designed with sustainability in mind. There are a number of factors that should be taken into account when designing active games for the purpose of exercise and physical promotion. These factors include the exercise intensity, duration and frequency [42]. Besides these factors, the entertainment and enjoyment factors play a significant role in active game design [42] [46].

Furthermore, there are two dimensions which are essential to the success and sustainability of Exergames. These dimensions are exercise game effectiveness and attractiveness. In the dimension of attractiveness, the 'flow concept' has been proposed. Flow is defined as "the state of total engagement in an activity" [42]. In order for the player to enter this flow state, a number of aspects should be considered such as the game challenges, player ability and skill and game interface, which is particularly important in Exergames. The Exergame interface and the game play should be smoothly integrated in order to not disrupt the players' attention. For example, if the game play requires the player's attention, the game interface should require minimal player attention. If game play and game interface are directly competing for player attention players may become distracted. The major consequence of this is the player not entering the 'flow state' [42].

The effectiveness dimension is closely related to the effectiveness of the Exergames to provide suitable exercise for the individuals in order to gain the health and fitness benefits. Based on these dimensions, the researchers in [42] proposed the Dual Flow model for the success of the Exergaming systems. For the attractiveness dimension, the 'flow state' is achieved by balancing game challenge and player skill. If this balance is not struck there are undesirable outcomes. For example, if the player skill exceeds game challenge, the player will enter in the boredom state. Similarly in the effectiveness dimension, there should be a balance between the players' fitness level and the exercise intensity in the game in order to

achieve the 'flow state'. If this does not occur, there are no physical benefits for the player [42].

The balance of challenge and skill in the attractiveness dimension in traditional video games could be achieved with the continuous test playing by targeted players in order to adjust the game challenge with the player skill. This adjustment suggests that as the player skill advances with time spent playing, the challenge level of the game should be increased in proportion in order to achieve the required balance. However, in Exergames the situation is different as the balance needs to be achieved in both dimensions; attractiveness and effectiveness. Therefore, the suggestion of increasing difficulty and intensity with the increased of the players' skills is not ideal as players would be exhausted with the high intensity and difficulty of exercising [42]. In this case the solution is to give players' the option of adjusting the game difficulty and intensity according to their skills and fitness level [42] [55]. Another solution is to design a simple game play that allows players to focus their attention on using the input device rather than on the game play such as in the DDR game [42].

More recent literature has considered the issue of balance and suggested a number of aspects that need to be considered when designing Exergames [54]. Firstly, the game should offer an equal opportunity for all players with different skill and fitness levels to play and win the game. Secondly, there should be a dynamic adjustment in Exergames where game difficulty is adjusted according to the players' abilities, skills and fitness levels in order to achieve the required balance. Thirdly, play duration is an important issue that needs to be considered and which should be linked with the required aim of fitness considering the fact that long periods of game play will lead to the player exhaustion. Fourthly, integrating the team mode within Exergame play would be effective and engaging as it motivates children to play together and share the responsibility of winning the game. Fifthly, balancing the rewarding approach within the game play is required because of its effectiveness in engaging players and motivating inactive players to continue play. Finally, including the punishment approach affects engagement in game [54]. Aside from these aspects, it is possible to develop engaging Exergames that are based on simple game play and simple motion sensors using a mobile platform as an Exergame controller [54].

B. Engagement

Other Literature was specifically interested in the ways to make Exergames more successful and engaging [46]. The first literature that attempted to clarify the link between what could motivate people to exercise and the design aspect of active video games was developed by [46]. There are a number of factors that assist in motivating people to exercise and therefore, need to be integrated in the exercise games design [46]. These factors include:

- Integrating the appropriate music to exercise games which should be related to the game theme. Music incorporation with exercise games has a positive effect as it increases the players' enjoyment and decreases negative feelings associated with physical exercise.

- Exercise games should provide guiding instructions which act as an exercise trainer especially for those who are beginners to exercising. These instructions should help players in their training sessions by providing the fitness knowledge and encouragement.

- Exercise games should provide short and long term goals using for example short quests to begin with and longer quests as players progress through the game. This design aspect supports the players' self-efficacy and motivates them to progress and regularly play the game.

- In a way to support the players' self-efficacy and provide a comfortable atmosphere for them to continually exercise, exercise games developers should not link game play actions with player fitness level.

- Some people find a lack of peers whilst exercising a factor that demotivates them to play Exergames. Game developers need to be aware of this and counteract it by providing a multiplayer mode capable of fostering online friendships. Whilst there are many positive aspect associated with exercise in a group environment, there are also draw backs. The authors commented that group exercise in certain circumstances can form a barrier to game play. These circumstances include individuals feeling that they are not as capable and fit as other players in the group and that they might 'let fellow players down'.

Taking into account conflicting requirements in game design, for example the positive and negative aspects of group play, game design needs to balance the factors outlined above. Based on the idea of merging and balancing these conflicting game design priorities, the authors in [46] have designed a game named Life is a Village which.

There is another proposed designing aspect that may support the game play of Exergames and lead to stronger engagement and immersion named 'haptic feedback' [46] [68]. 'Haptic feedback' is a concept that is related to the tactile sense which appears as a sensual response resulting from a physical activity in real world. For example, when people play Tennis, they feel the vibration of the tennis racket when hitting the tennis ball or when a person pedals a bicycle on a road, he or she feels the power in his leg while pedalling and the vibration of his hand while steering. This tactile sense helps connect real world experience with the virtual world and this connection makes the game more engaging and enjoyable. Incorporating this technique in Exergames could improve three issues related to this area. These issues are [68]:

- 'Balancing' where the haptic feedback can be used to facilitate group play of players with different abilities and skills.

- 'Safe and healthy interaction' where haptic feedback can be used to control the exercise level and intensity by motivating players to an effective level of exercise.

- 'Presence' where the haptic feedback can be used in order for players to have stronger immersion in the virtual world.

Based on these three aspects, the study [68] developed three Exergames using the haptic feedback technique. Each of the three Exergames was developed in two versions; one with a haptic feedback and one without it. The evaluation of these games demonstrated that for the two of the games the majority of participants preferred the haptic versions to the non-haptic versions. In the third game players preferred the non-haptic version. This was because the haptic feedback in this game was inconsistent with the real world. In general, haptic feedback was found to enhance game play and make it more realistic as well as causing greater player immersion. However, some Exergame interfaces cannot support the implementation of the haptic feedback because of the absence of a physical tool that delivers the haptic feedback to the player for example there is no tool for haptic feedback with regard to vision-based devices such as Microsoft's Kinect Sensor.

C. Fitness

There are a number of recommendations for exercise game developers that need to be considered in order to support player fitness [42] [46] [55]:

- Integrating warm-up and cool-down activities in game play as they are essential to exercise.

- Exercise games should encourage players exercise according to their fitness abilities.

- Players should be given the freedom to choose the duration of the play

- Adequate hearth rate should be maintained at all times during game play for example heart rate should not be allowed to significantly decrease whilst new screens are loading

- It is recommended that physiological measures relating to the players are displayed on the screen to allow players to monitor their progress and fitness levels.

- It is also recommended that dynamic game play is adjusted according to the players' level of fitness so that they are able to achieve set goals.

D. Activity levels

Designing active games for the purpose of exercising is usually associated with increasing the players' physical activity. A number of areas need to be considered in order to achieve this purpose[45]:

- Exergames systems should use accurate sensors in order to detect whole body movement, so that players are unable to cheat.

- Player's physical interactions should aim to involve full body movement rather than just movement of small body parts such as limbs in order to gain greater health benefits.

- Exergames should involve an element of incentive to continuously motivate players to remain physically active over long periods of time.

- In order to achieve a long term motivation, Exergames should not focus on weight loss but rather areas such as social interaction, competition and quest completion.

E. How to Make Active Video Games More Engaging

In order to reap the benefits of active video games, it is important to make them more appealing and engaging, so the players are motivated to achieve the implicit purpose of these games. The researchers in [57] suggested that physical activity in active video game play should mimic real world activity in order to achieve this purpose. For example, when developing an active video game that aims to help children learn how to play tennis, it is recommended that the game is designed in a way that simulates a real tennis game. Moreover, this game should be fun and engaging so players are encouraged to play more and more. Whilst ever players are having fun they will continue to acquire new skills [57].

The study [38] stated that active video games that are based on exploration and challenges combined with a game story could enable the player to forget about the physical exertion that he or she is undertaking. However, while exploration is a positive aspect of video gaming, players might find navigating in a large three-dimensional virtual world to be overwhelming and difficult. Moreover, the player's may become distracted if they are required to focus too much on their placement in relation to a physical device. This is particularly true of active video games that utilize physical interfaces such as pads and mats. Active game developers need to be aware of this and provide tools to assist players in navigating in the virtual world to ensure that they stay on track in the game so that they are able to achieve the end goal [38].

F. Motivations and Barriers to Playing Active Video Games

There are a number of motivators that encourage children to play active video games as well as a number of barriers that could discourage them from playing active video games. One study [37] conducted a number of focused group interviews among 37 children and 27 parents or guardians in order to discuss the parents' and children's perceptions of motivators and barriers to active video game play. Younger boys preferred games with content that was aggressive in manner whereas girls preferred dancing and singing contents. Older girls preferred more challenging games [37]. On the other hand, parents preferred their children to play active video games that had realistic, nonviolent contents and that involved dance, sport and music [37].

1) Motivations

Most boys, regardless of age were motivated to play games that involved lots of fighting and killing [37]. However, with active gaming that requires physical body interaction younger boys stated that they were willing to play these games because of their potential to increase fitness. Older boys stated that they would prefer to play sport in real life than play active video games. On the other hand, younger girls were motivated to play

active games that included singing and dancing contents while older girls were more motivated to play games that offered social interaction and that help control body weight. This source indicated overall that active video games are more appealing to younger males and females. On the whole, older boys and girls preferred to be involved in real-life sport than simulated physical activity in active video games. This is due to the perception by older children that sport is more sociable and enjoyable in the natural environment [37].

Furthermore, other literature discussed further motivators that could encourage children to play these games over a long period of time in order to achieve their benefits [69]. The authors in [69] proposed the idea of conducting a weekly multiplayer active video game session in order to motivate children to play. This idea was evaluated over a 12 week period of time using 27 children aged between 9 and 12 years who were divided into two groups, a home group and a multiplayer group. Both groups were provided with an interactive dance simulation video game to be played in their homes with the freedom to play as much as they desired. The participants were asked to record their playing times. The multiplayer group was asked to attend a weekly multiplayer session whilst the home group was not. In this multiplayer session, the children were motivated to play together and experience the atmosphere of competition and social interaction. The results of this study demonstrated the effectiveness of this idea as the game play rate of the multiplayer group was double the game play rate of the home group and the dropout rate in the multiplayer group was lower than the home group. The median play duration in the last 6 weeks was decreased in the home group and increased in the multiplayer group [69].

Additional literature studied the link between the game motivation and the player movements in active video games [67]. Two strategies have been introduced to describe this link. These strategies include:

- The Game strategy where the player is motivated to achieve a high score. This has negative implications for increasing player physical activity as players become preoccupied with achieving high scores to the extent that they will minimize active movement for example players figure out that a small wrist flick in a tennis game is effective in helping them achieve a high score so they cease to move their entire arm.

- The Simulation strategy where there is no competition or score to achieve and players are actually motivated to simulate real like games like tennis. In this circumstance players are more mentally relaxed and focused on replicating the required sporting motions.

2) Barriers
There are a number of barriers which discourage children from playing active video games including their involvement in other unavoidable everyday activities as well as a loss of interest in active video games because of their ease of availability in the home environment. Moreover, active video games may present less of a challenge compared traditional inactive games and this may act as demotivation. Furthermore, the lack of space in home environment as well as the cost of

these games contributes to discouraging parents and guardians from buying these games for their children [37].

X. BENEFITS OF ACTIVE VIDEO GAMES

Active video games have a number of benefits for children who are associated with their development [37] [16]:

- Physical and health benefits.

- Improvement in physiological outcomes.

- Motor and skill development in a safe environment especially for in children with disabilities.

- The positive aspects that are associated with home-based exercising including being supervised by parents as well as safe and comfortable atmosphere to exercise especially for obese and overweight children who experience self-esteem issues when exercising in public areas.

- Reading and social skill development.

- Avoidance of bad weather conditions outside.

- Having the opportunity to be involved in a variety of physical activity that they might not have had the opportunity to be involved in otherwise.

- Help them find their favorite sport and encourage them to practice it in the real world.

XI. TECHNICAL ISSUES

There is a large about of literature which focuses on the technical aspect of active video gaming systems. In the area related to the interface of the active gaming systems, researchers [70] proposed a human-computer interface for active video games that uses a single camera and relies on the player's body pose to control the game without using any hand-held controllers. This proposed system named "Wii Using Only 'We'" involves two main steps in its algorithm: background subtraction and human pose recognition. Evaluation of this system demonstrated that good performance as a new gaming interface depends on the human pose and is not related to physical controls [70].

The authors in [71] proposed a multimodal interaction method to control game play in active video games. This method relies on the movement of two hands, one hand to hold the physical controller and the other hand to perform gestures. A 3D camera is used to detect hand motion. This method offers a one-on-one interaction with on-screen actions. For example, one of the developed games which implement this method uses one hand to perform a "force push" gesture and the other hand to hold a controller like a sword in order to fight the enemies in the game. By processing hand gestures and detecting the position of the physical controller, the player is able to advance in the virtual world. Evaluation this method demonstrated its effectiveness in engaging players as they are able to use their both hands to play which more closely simulates real life experience [71].

XII. FOCUS OF STUDY

After reviewing the literature in this area a number of issues have been raised. Previously playing video games has been defined as a sedentary activity. There is much evidence in existing literature that sedentary activities have been linked to childhood obesity. As playing video games is a preferred leisure activity among children and adolescents, it is important that a means of converting this activity from passive to active is developed.

The statistics discussed in the introduction of this paper demonstrated that over the past several decades there has been a significant increase in the number of obese and overweight children throughout the world. This increase in childhood obesity has been associated with different diseases. The problem of obesity and its subsequent effects can be reduced by increasing physical activity in children according to the daily physical activity recommendations [14].

Substituting traditional video games with active video games means replacing a previously sedentary activity with an active one. Active video games that involve whole body movement are more beneficial than those which require only small localized movements of some of body parts. Our research going forward will focus on Microsoft's Kinect platform as an interface for active video games which relies on whole body movement to control the virtual world without the need for a game controller. In this way the player uses their body as the controller.

Finally, in order to reap the largest benefits for positive health outcomes, active video games need to be motivating and engaging in their promotion of physical activity. Whilst active video games may not provide the same health benefits as real sports, they certainly have the potential to decrease the amount of time children spent undertaking sedentary behavior. Active video games are a valuable step forward in tackling the problem of childhood obesity.

XIII. CONCLUSION

It has been conclusively demonstrated that there is an association between increasing rates of childhood obesity and children engaging in screen based activity. In response to this issue, the idea of converting passive screens to be active ones has been raised. Active video games are showing large amounts of promise in this area. They provide the opportunity for the integration of physical activity into a pastime that has been well established as something children enjoy. Playing video games that force the player to physically interact in order to control the game play is an effective intervention to active play in the future.

The aim of our research is to develop an active game prototype that relies on players' movement which is especially targeted at children. The purpose of this prototype is to engage children in game play that motivates them to exercise. In this way, they are able to have fun whilst being involved age-appropriate levels of physical activity. In order to achieve this, previous work that has been done in the area of active video games was reviewed and detailed in this paper.

REFERENCES

[1] T. J. Lobstein, W. P. T. James, and T. J. Cole, "Increasing levels of excess weight among children in England," Int J Obes Relat Metab Disord, vol. 27, pp. 1136-1138, 2003.

[2] M. L. Booth, M. Wake, T. Armstrong, T. Chey, K. Hesketh, and S. Mathur, "The epidemiology of overweight and obesity among Australian children and adolescents, 1995-97," Australian and New Zealand Journal of Public Health, vol. 25, pp. 162-168, 2001.

[3] C. L. Ogden, M. D. Carroll, L. R. Curtin, M. A. McDowell, C. J. Tabak, and K. M. Flegal, "Prevalence of Overweight and Obesity in the United States, 1999-2004," JAMA: The Journal of the American Medical Association, vol. 295, pp. 1549-1555, April 5, 2006 2006.

[4] C. L. Ogden, M. D. Carroll, B. K. Kit, and K. M. Flegal, "Prevalence of Obesity and Trends in Body Mass Index Among US Children and Adolescents, 1999-2010," JAMA: The Journal of the American Medical Association, vol. 307, pp. 483-490, February 1, 2012 2012.

[5] P. G. Kopelman, "Obesity as a Medical Problem," vol. 404, 6 APRIL 2000 2000.

[6] M. S. Tremblay and J. D. Willms, "Is the Canadian childhood obesity epidemic related to physical inactivity?," Int J Obes Relat Metab Disord, vol. 27, pp. 1100-1105, 2003.

[7] S. L. Wong and S. T. Leatherdale, "Association between sedentary behavior, physical activity, and obesity: inactivity among active kids," Prev Chronic Dis vol. 6, 2009.

[8] M. M. Carvalhal, M. C. Padez, P. A. Moreira, and V. M. Rosado, "Overweight and obesity related to activities in Portuguese children, 7–9 years," The European Journal of Public Health, vol. 17, pp. 42-46, December 6, 2006 2006.

[9] R. E. Andersen, C. J. Crespo, S. J. Bartlett, L. J. Cheskin, and M. Pratt, "Relationship of Physical Activity and Television Watching With Body Weight and Level of Fatness Among Children," JAMA: The Journal of the American Medical Association, vol. 279, pp. 938-942, March 25, 1998 1998.

[10] E. A. Vandewater, M.-s. Shim, and A. G. Caplovitz, "Linking obesity and activity level with children's television and video game use," Journal of Adolescence, vol. 27, pp. 71-85, 2004.

[11] P. Gordon-Larsen, R. G. McMurray, and B. M. Popkin, "Determinants of Adolescent Physical Activity and Inactivity Patterns," Pediatrics, vol. 105, p. e83, June 1, 2000 2000.

[12] D. A. Cohen, J. S. Ashwood, M. M. Scott, A. Overton, K. R. Evenson, L. K. Staten, D. Porter, T. L. McKenzie, and D. Catellier, "Public Parks and Physical Activity Among Adolescent Girls," Pediatrics, vol. 118, pp. e1381-e1389, November 2006 2006.

[13] R. Maddison, L. Foley, C. Ni Mhurchu, Y. Jiang, A. Jull, H. Prapavessis, M. Hohepa, and A. Rodgers, "Effects of active video games on body composition: a randomized controlled trial," The American Journal of Clinical Nutrition, vol. 94, pp. 156-163, July 1, 2011 2011.

[14] W. B. Strong, R. M. Malina, C. J. R. Blimkie, S. R. Daniels, R. K. Dishman, B. Gutin, A. C. Hergenroeder, A. Must, P. A. Nixon, J. M. Pivarnik, T. Rowland, S. Trost, and F. Trudeau, "Evidence Based Physical Activity for School-age Youth," The Journal of Pediatrics, vol. 146, pp. 732-737, 2005.

[15] J. Fromme, "Computer Games as a Part of Children's Culture," Game Studies The International Journal of Computer Game Research vol. 3, 1 May 2003 2003.

[16] A. J. Daley, "Can Exergaming Contribute to Improving Physical Activity Levels and Health Outcomes in Children?," Pediatrics, vol. 124, pp. 763-771, August 2009 2009.

[17] M. Papastergiou, "Exploring the potential of computer and video games for health and physical education: A literature review," Computers & Education, vol. 53, pp. 603-622, 2009.

[18] E. Biddiss and J. Irwin, "Active Video Games to Promote Physical Activity in Children and Youth: A Systematic Review," Arch Pediatr Adolesc Med, vol. 164, pp. 664-672, July 1, 2010 2010.

[19] R. Mark, R. Rhodes, D. E. R. Warburton, and S. Bredin, "Interactive Video Games and Physical Activity: A Review of the Literature and Future Directions," The Health & Fitness Journal of Canada, vol. 1, December 31, 2008 2008.

[20] M. J. Wolf, The Medium of the Video Game University of Texas Press 2001.

[21] M. J. P. Wolf and B. Perron, The Video GameTheory Reader Routledge, 2003.

[22] F. Bellotti, R. Berta, A. D. Gloria, and L. Primavera, "Enhancing the educational value of video games," Comput. Entertain., vol. 7, pp. 1-18, 2009.

[23] T.-Y. Chuang and Wei-Fan, "Effect of Computer-Based Video Games on Children: An Experimental Study," in Digital Game and Intelligent Toy Enhanced Learning, 2007. DIGITEL '07. The First IEEE International Workshop on, 2007, pp. 114-118.

[24] M. d. Aguilera and A. Mendiz, "Video games and education: (Education in the Face of a “Parallel School”)," Comput. Entertain., vol. 1, pp. 1-10, 2003.

[25] C. Intratat, "Alternatives for Making Language Learning Games More Appealing for Self-Access Learning," Studies in Self-Access Learning Journal, vol. 2, pp. 136-152, September 2011.

[26] M. Kam, A. Mathur, A. Kumar, and J. Canny, "Designing digital games for rural children: a study of traditional village games in India," presented at the Proceedings of the 27th international conference on Human factors in computing systems, Boston, MA, USA, 2009.

[27] D. A. Lieberman, "Management of Chronic Pediatric Diseases with Interactive Health Games: Theory and Research Findings," The Journal of Ambulatory Care Management, vol. 24, pp. 26-38, 2001.

[28] R. Maddison, C. N. Mhurchu, A. Jull, Y. Jiang, H. Prapavessis, and A. Rodgers, "Energy expended playing video console games: an opportunity to increase children's physical activity?," Pediatric Exercise Science vol. 19, pp. 334-343, 2007.

[29] R. R. Mellecker and A. M. McManus, "Energy Expenditure and Cardiovascular Responses to Seated and Active Gaming in Children," Arch Pediatr Adolesc Med, vol. 162, pp. 886-891, September 1, 2008 2008.

[30] L. Graves, N. Ridgers, and G. Stratton, "The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii," European Journal of Applied Physiology, vol. 104, pp. 617-623, 2008.

[31] Y. Chen Yoke, S. Sivapalan, K. Ganeson, N. Goh Kim, K. S. Sugathan, E. Akashah, and P. Akhir, "Design of web intervention to influence youth behavior toward online gaming," in Information Technology (ITSim), 2010 International Symposium in, 2010, pp. 1368-1371.

[32] P. Sweetser and P. Wyeth, "GameFlow: a model for evaluating player enjoyment in games," Comput. Entertain., vol. 3, pp. 3-3, 2005.

[33] M. Dickey, "Engaging by design: How engagement strategies in popular computer and video games can inform instructional design," Educational Technology Research and Development, vol. 53, pp. 67-83, 2005.

[34] C. Pearce, "Towards a Game Theory of Game," ed, 2004.

[35] P. Vorderer, T. Hartmann, and C. Klimmt, "Explaining the enjoyment of playing video games: the role of competition," presented at the Proceedings of the second international conference on Entertainment computing, Pittsburgh, Pennsylvania, 2003.

[36] G. Chanel, C. Rebetez, M. B\, \#233, trancourt, and T. Pun, "Boredom, engagement and anxiety as indicators for adaptation to difficulty in games," presented at the Proceedings of the 12th international conference on Entertainment and media in the ubiquitous era, Tampere, Finland, 2008.

[37] R. Dixon, R. Maddison, C. Ni Mhurchu, A. Jull, P. Meagher-Lundberg, and D. Widdowson, "Parents' and children's perceptions of active video games: a focus group study," Journal of Child Health Care, vol. 14, pp. 189-199, June 1, 2010 2010.

[38] B. M. Winn, P. Wei, and K. Pfeiffer, "Player guiding in an active video game," in Games Innovation Conference (IGIC), 2011 IEEE International, 2011, pp. 107-108.

[39] S. G. Martinez, "Motion-Based Video Games Reach a New Audience: The Elderly," in TECH COCKTAIL, ed, 2011.

[40] T. Stach, T. C. N. Graham, M. Brehmer, and A. Hollatz, "Classifying input for active games," presented at the Proceedings of the International Conference on Advances in Computer Enterntainment Technology, Athens, Greece, 2009.

[41] M. Brehmer, T. C. N. Graham, and T. Stach, "Activate your GAIM: a toolkit for input in active games," presented at the Proceedings of the International Academic Conference on the Future of Game Design and Technology, Vancouver, British Columbia, Canada, 2010.

[42] J. Sinclair, P. Hingston, and M. Masek, "Considerations for the design of exergames," presented at the Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia, Perth, Australia, 2007.

[43] C. Ni Mhurchu, R. Maddison, Y. Jiang, A. Jull, H. Prapavessis, and A. Rodgers, "Couch potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children," International Journal of Behavioral Nutrition and Physical Activity, vol. 5, p. 8, 2008.

[44] R. MARK and R. E. RHODES, "Active Video Games: A Good Way to Exercise?," WellSpring, vol. 20, 2009.

[45] A. Whitehead, H. Johnston, N. Nixon, and J. Welch, "Exergame effectiveness: what the numbers can tell us," presented at the Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games, Los Angeles, California, 2010.

[46] J. Yim and T. C. N. Graham, "Using games to increase exercise motivation," presented at the Proceedings of the 2007 conference on Future Play, Toronto, Canada, 2007.

[47] A. Karime, H. Al Osman, W. Gueaieb, J. M. Alja'am, and A. El Saddik, "Learn-pads: A mathematical exergaming system for children's physical and mental well-being," in Multimedia and Expo (ICME), 2011 IEEE International Conference on, 2011, pp. 1-6.

[48] J. C. Yang, Y. L. Lin, J. J. Wu, and K. H. Chien, "Design and Evaluation of a Physical Interactive Learning Environment for English Learning," in Digital Games and Intelligent Toys Based Education, 2008 Second IEEE International Conference on, 2008, pp. 36-43.

[49] H.-J. Lee, H. Kim, G. Gupta, and A. Mazalek, "WiiArts: creating collaborative art experience with WiiRemote interaction," presented at the Proceedings of the 2nd international conference on Tangible and embedded interaction, Bonn, Germany, 2008.

[50] B. Lange, C. Chien-Yen, E. Suma, B. Newman, A. S. Rizzo, and M. Bolas, "Development and evaluation of low cost game-based balance rehabilitation tool using the microsoft kinect sensor," in Engineering in Medicine and Biology Society,EMBC, 2011 Annual International Conference of the IEEE, 2011, pp. 1831-1834.

[51] T. Morelli, J. Foley, and E. Folmer, "Vi-bowling: a tactile spatial exergame for individuals with visual impairments," presented at the Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility, Orlando, Florida, USA, 2010.

[52] T. Morelli, J. Foley, L. Lieberman, and E. Folmer, "Pet-N-Punch: upper body tactile/audio exergame to engage children with visual impairments into physical activity," presented at the Proceedings of Graphics Interface 2011, St. John's, Newfoundland, Canada, 2011.

[53] T. Morelli, J. Foley, L. Columna, L. Lieberman, and E. Folmer, "VI-Tennis: a vibrotactile/audio exergame for players who are visually impaired," presented at the Proceedings of the Fifth International Conference on the Foundations of Digital Games, Monterey, California, 2010.

[54] K. Kiili and S. Merilampi, "Developing engaging exergames with simple motion detection," presented at the Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland, 2010.

[55] B. K. Smith, "Physical fitness in virtual worlds," Computer, vol. 38, pp. 101-103, 2005.

[56] C. Delgado-Mata, R. Ruvalcaba-Manzano, O. Quezada-Patino, D. Gomez-Pimentel, and J. Ibanez-Martinez, "Low cost video game technology to measure and improve motor skills in children," in AFRICON, 2009. AFRICON '09., 2009, pp. 1-6.

[57] F. Peer, A. Friedlander, A. Mazalek, and F. F. Mueller, "Evaluating technology that makes physical games for children more engaging," presented at the Proceedings of the 10th International Conference on Interaction Design and Children, Ann Arbor, Michigan, 2011.

[58] D. L. Graf, L. V. Pratt, C. N. Hester, and K. R. Short, "Playing Active Video Games Increases Energy Expenditure in Children," Pediatrics, vol. 124, pp. 534-540, August 2009 2009.

[59] L. Lanningham-Foster, T. B. Jensen, R. C. Foster, A. B. Redmond, B. A. Walker, D. Heinz, and J. A. Levine, "Energy Expenditure of Sedentary Screen Time Compared With Active Screen Time for Children," Pediatrics, vol. 118, pp. e1831-e1835, December 2006 2006.

[60] L. Lanningham-Foster, R. C. Foster, S. K. McCrady, T. B. Jensen, N. Mitre, and J. A. Levine, "Activity-Promoting Video Games and Increased Energy Expenditure," The Journal of Pediatrics, vol. 154, pp. 819-823, 2009.

[61] L. Graves, G. Stratton, N. D. Ridgers, and N. T. Cable, "Energy expenditure in adolescents playing new generation computer games," British Journal of Sports Medicine, vol. 42, pp. 592-594, July 1, 2008 2008.

[62] S. R. SIEGEL, B. L.HADDOCK, A. M. DUBOIS, and L. D. WILKIN, "Active Video/Arcade Games (Exergaming) and Energy Expenditure in College Students," Int J Exerc Sci, vol. 2, pp. 165–174, 2009.

[63] K. White, G. Schofield, and A. E. Kilding, "Energy expended by boys playing active video games," Journal of Science and Medicine in Sport, vol. 14, pp. 130-134, 2011.

[64] A. E. Maloney, T. Carter Bethea, K. S. Kelsey, J. T. Marks, S. Paez, A. M. Rosenberg, D. J. Catellier, R. M. Hamer, and L. Sikich, "A Pilot of a Video Game (DDR) to Promote Physical Activity and Decrease Sedentary Screen Time," Obesity, vol. 16, pp. 2074-2080, 2008.

[65] J. Whitson, C. Eaket, B. Greenspan, M. Q. Tran, and N. King, "Neo-immersion: awareness and engagement in gameplay," presented at the Proceedings of the 2008 Conference on Future Play: Research, Play, Share, Toronto, Ontario, Canada, 2008.

[66] S. Bjork and J. Holopainen, Patterns in Game Design Jenifer Niles, 2005.

[67] M. Pasch, N. Bianchi-Berthouze, B. van Dijk, and A. Nijholt, "Movement-based sports video games: Investigating motivation and gaming experience," Entertainment Computing, vol. 1, pp. 49-61, 2009.

[68] T. Stach and T. Graham, "Exploring Haptic Feedback in Exergames Human-Computer Interaction – INTERACT 2011." vol. 6947, P. Campos, N. Graham, J. Jorge, N. Nunes, P. Palanque, and M. Winckler, Eds., ed: Springer Berlin / Heidelberg, 2011, pp. 18-35.

[69] M. J. M. Chin A Paw, W. M. Jacobs, E. P. G. Vaessen, S. Titze, and W. van Mechelen, "The motivation of children to play an active video game," Journal of Science and Medicine in Sport, vol. 11, pp. 163-166, 2008.

[70] D. Yuanqiang, D. Conrad, and G. N. DeSouza, "“Wii Using Only ‘We’”: Using background subtraction and human pose recognition to eliminate game controllers," in Robotics and Automation (ICRA), 2011 IEEE International Conference on, 2011, pp. 3887-3892.

[71] D. Ionescu, B. Ionescu, C. Gadea, and S. Islam, "A Multimodal Interaction Method that Combines Gestures and Physical Game Controllers," in Computer Communications and Networks (ICCCN), 2011 Proceedings of 20th International Conference on, 2011, pp. 1-6.